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# A REVIEW OF THE 1938 LITERATURE PERTAINING TO THE FIELD OF CEREAL CHEMISTRY[1]

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This is a continuation of the series of similar papers presented at previous meetings by Clinton L. Brooke (1936). Because of the rather short time available for the preparation of this article, it was thought advisable not to select a large number of references, but to discuss the data and conclusions in somewhat greater detail. Let us divide the subject, considering first whole grain, then flour, and finally bread.

During the past year the fumigation of grain has attracted attention. Although carbon disulphide has been in use for this purpose since 1857, its inflammability and odor make it highly objectionable. Furthermore, Cayzer (1938) has shown that carbon disulphide has a decided weakening effect on the gluten, although after storage for two months the flour improved as did the control through natural aging. The carbon-disulphide-treated flours when baked soon after milling gave small "green" loaves by both the malt-phosphate and the malt-phosphate-bromate procedures. The doughs made from the $CS_2$-treated flours were of poor handling quality and the texture of the bread was coarse and heavy. The possibility that this is another case of SH oxidation is mentioned.

Cayzer (1938) also tested a mixture of 75% ethylene dichloride and 25% carbon tetrachloride as a fumigant. This mixture was found quite effective in the control of insects and had no weakening effect on gluten quality as shown by the farinograph. Loaf-volume measurements indicated further that there is close correlation between farinograph and baking results.

The conditioning of grain prior to milling is probably the most important technical question now confronting the milling industry. Much of the practical experience of the past and many of the isolated opinions of specialists can now be united to form the beginning of a

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theory of this process. Besides the well-known factors of temperature, moisture, and time, there are unexpected relationships involving the chemical and perhaps the enzymic composition of the grain. Which of these are the most important and which can be neglected in practice? How far do laboratory results help to decide this question?

In any case it seems evident that the utilization of each new crop requires that attention be given to the conditioning of the grain. Ritter (1938) makes the point that the effect of relatively high conditioning temperatures is a neglected but important factor in the milling of grain. Mueller (1938) is of the opinion that no one procedure gives good results with all kinds of wheat.

Issue No. 22, Vol. 75, of *Die Mühle* is a special edition on wheat conditioning. Boulanger (1938) discusses whether the baking and milling qualities are really affected by conditioning, and concludes that they are very much so. Argus (1938) points to the incompleteness of definite knowledge and the present opportunities for misunderstanding between mill and laboratory. Berliner (1938) considers changes in the interior of the grain of the highest importance, particularly partial denaturation of the proteins and modifications of enzyme activity as produced by heat and the chemical effect of the added water. Hübsch (1938) on the other hand is inclined to minimize the importance of enzyme changes, and regards alterations in the viscosity of starch and proteins as of chief interest. This author differs from most current writers in being far from convinced that conditioning grain improves the baking qualities of flour.

Ritter (1938) considers that the enzymes of most probable importance in conditioning are first the starch-splitting ferments $\alpha$- and $\beta$-amylase and the newly discovered amylophosphatase. Proteinases, peptidases, phosphatases, the enzymes of oxidation and reduction, and in fact most of the other known ferments come in for attention, however. These enzymes are thought to play a double role in the wheat; during ripening they synthesize and during conditioning and baking they break down starch, protein, and other constituents.

It is only a step from the conditioning of wheat to studies on changes during germination. Thus Pulkki and Puutula (1938) found that during the germination of a Manitoba wheat ascorbic acid occurred in the sprouts to an extent far outweighing that found in the rest of the grain. The maximum amount of ascorbic acid found was 0.022% on dry weight. The sprout also contains a substance having considerable proteolytic activity, in fact so much that the proteolytic activity far overcomes the effect of the ascorbic acid on the baking strength. The grain with sprout removed contained most of the amylase.

Kosmina and Romanova (1938) found that up to the fourth or fifth

day of sprouting the gluten content of wheat grain undergoes only a small decrease. In the course of the sprouting the ordinarily smooth and elastic gluten becomes crumbly and is easily torn; accordingly the dough shows poor elasticity and the volume of the bread is reduced.

The cause of these alterations in the gluten quality is said to be the hydrolysis of fat in the sprouting grain, leading to an accumulation of unsaturated fatty acids which exert an influence on the colloidal properties of the gluten. The sprouting process also influences the activation of proteolytic enzymes capable of digesting gluten. The authors, however, regard the effects of fatty acids and proteinase activity as opposing each other, for no liquefaction of gluten was observed until removal of the fatty acids from the flour.

Mounfield (1938) presents the third paper in a series on the proteolytic enzymes of sprouted wheat. He has previously reported the properties of the proteinase and dipeptidase in water extracts of sprouted wheat. The present paper deals primarily with the action of the proteinase on gelatin, ovalbumin, gliadin, glutenin, and gluten as shown by changes in formal titrations. Wheat proteinase was found to hydrolyze gelatin at pH 5.1 and wheat gluten at pH 6, but did not attack ovalbumin and affected isolated glutenin and gliadin only slightly. Activation of wheat proteinase by cyanide was observed when edestin was the substrate but not when gluten was employed.

Of the many interesting studies on flour and its constituents, only a few can be reported here.

Practical importance attaches to a photoelectric colorimeter described by Palmer (1939), which measures color in terms of the percentage of light absorbed in different parts of the spectrum. The surface of the flour is illuminated by light of controlled intensity falling on it at an angle of 45 degrees. The reflected light is filtered through a cell containing copper sulphate solution and is then passed through color filters that are so mounted as to be changed readily. After passing through the filter the colored light falls on the photoelectric cell, which is connected with a reflecting galvanometer. Nine color filters are recommended. The color of the flour can be described in terms of brightness, grayness, and yellowness. The recording of the color values of a flour occupies about five minutes. The instrument can also be used for measuring color in bread. A definite improvement of color was noted in flour after aging for 21 days.

Jørgensen (1938) has continued his work on the effect of bromate in the dough, and has secured additional evidence for the view that the change in gluten is due to inhibiting the action of a papain-like proteinase in the flour. It was found that very low concentrations (0.002 molar) of bromate and iodate strongly inhibited the digestion

of casein by papain, whereas chlorate did not inhibit, even in large amounts. Furthermore, and in contradiction to earlier observations, these inhibitions were not dependent on the type of buffer used. Iodate and bromate, but not chlorate, also inhibit bromelin, and since the presence of these inhibitors also reduces the amount of water-soluble nitrogen that may be extracted from a flour, it follows that they inhibit the flour proteinase as well. The article by Jørgensen, cited here, is one of several papers of great interest to cereal chemists, which appear in the volume of *Carlsberg's Comptes Rendues* commemorating the 70th birthday of S. P. L. Sörensen.

The discovery by Jørgensen in 1935 that ascorbic acid was a good bread improver has increased the interest of cereal chemists in this substance. Ascorbic acid was already known to inhibit the activity of papain, but this cannot be due to oxidation, for ascorbic acid is a strong reducing agent. Jørgensen, in order to explain the effect in dough, advanced the view that it might act as an oxygen carrier, absorbing oxygen from the atmosphere and then in turn oxidizing the flour proteinase. This is in agreement with the remarkable observation of Hopkins and Morgan (1936) that when reduced glutathione and ascorbic acid are mixed in the presence of ascorbic acid oxidase and air, the glutathione is oxidized first, and not until all the glutathione is gone does the ascorbic acid undergo oxidation.

More recently Melville and Shattock (1938) have shown that flour contains ascorbic acid oxidase, and that dehydroascorbic acid is usually a better bread improver than the reduced form. So the connections among ascorbic acid, glutathione, certain oxidative enzyme systems, and the quality of gluten seem well established.

The behavior of flour is of course not the only factor in the quality of the dough. Fermentation is an important part of the baking process, and Hofman and Hanke (1938) have made a recent study on the stimulation of fermentation caused by the addition of organic acids. Farinograph measurements, coupled with observations on the gas generated, have shown that fermentation was stimulated by the addition of about 0.25% lactic acid and 0.13% acetic acid, while addition of butyric acid was without result. With these organic acids it is necessary to use a larger dose of yeast, for the increased acidity may favor the development of wild organisms.

While the enzyme systems of flour and particularly their capacity for modifying the gluten have thus received much attention, the structure and physical properties of both flour protein and starch have been discussed in numerous papers.

Ritter (1939) notes that the intake of water by gluten which has been stretched and then allowed to dry causes a swelling that increases

the thickness of the gluten strands far more than it increases their length. Such observations emphasize the fiber-like structure of flour protein. However, certain soluble proteins of small molecular weight —myosin, for example—can be transformed into fibers, and this seems to show a close connection between proteins of both kinds. It is only necessary to dissolve myosin and reprecipitate it while the particles have a linear motion in order to obtain a fibrous form.

Schmorl (1938) has summarized the present-day knowledge of starch in a chemical formula that seeks to explain the physical property of gel-formation and such chemical facts as the phosphorus content, the capacity for further phosphorylation by a phosphorylizing enzyme, and the difference in hydrolysis produced by the two types of amylase. The modern tendency seems to be to regard the colloidal properties of starch as being due to peculiarities in the chemical build-up rather than to "outside" factors.

Passing at last from flour and dough to bread itself, mention should be made of two of the most important problems in the field, the staling of bread and the flavor of bread.

A paper by Fuller (1938) presents an interesting report on the problem. The author states that bread goes stale in spite of many patent remedies. The work and theories of Platt, Alsberg, Katz, and Ostwald are discussed fully.

A study of the structure and properties of starch appears relevant to the problem. That starch is the fraction of the bread most directly concerned in staling appears to have been definitely established; furthermore, staling is apparently due to a reduction in the hydration capacity of the gelatinized starch which causes a change in the structure of the gel.

Partial disaggregation of the starch molecules occurs on heating, thus altering the proportion of $\alpha$ and $\beta$ amylose, and there would appear to be a definite equilibrium between the two forms at any one temperature. It is suggested that to the comparatively slow attainment of equilibrium between the two forms may be attributed the phenomenon of staling. If this is so, then staling can only be affected by a major alteration in the equilibrium proportion of $\alpha$ and $\beta$ amylose, such as would be obtained by keeping the bread at an elevated temperature or by altering the state of hydration of the starch present.

One method of altering the state of hydration of the starch is by freezing, another method is by adding soluble solids such as sugar. A third possibility is the discovery of some edible substance that, when added to the starch gel, will prevent molecular reaggregation.

In reference to the flavor question, attention is called to a paper by Maybee (1939). This paper discusses theories of the flavor, odor,

and taste of foods in general. The following subjects are also treated: relation of flavor to constitution; classification of flavor sensations, synthetic flavors, subsidiary flavors developed during storage; the threshold value, sweet, bitter, sour and salty taste, classifications of odor sensations, food-tasting panels; and methods of measurement that can be standardized in the control laboratory.

A paper by Pelshenke (1938) discusses reasons for the decline in bread consumption. The flavor of bread, it is stated, is governed above all by the type. Some countries have bread of a decided yeasty or sour taste, others with a neutral taste. The influence of raw materials and improvers plays an important role in taste and flavor. Flour is almost tasteless, and if the bread is to be pleasing this must come about through other ingredients. In particular, two groups of substances govern the flavor of bread, namely the soluble disintegration products of starch that are formed during fermentation and the products in the crust formed during baking. The main problem is to treat the bread so that these bodies will be produced. Beyond a doubt the speed and the acceleration of the fermentation process can be accomplished only at the expense of the development of flavor. The addition of pleasantly aromatic organic compounds to the dough is impractical as they are volatile and so are lost during baking. Influencing factors such as improvers, ovens, and dough conditions are also discussed.

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## NOMOGRAMS FOR CALCULATING ABSORPTION OF FLOUR AND SEMOLINA [1]

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Where a large number of tests is involved, the arithmetical calculation of flour and semolina absorption from baking and macaroni test data is tedious and time-consuming. These computations have recently been replaced in this laboratory by the use of nomograms. These have proved so convenient that it has been thought worth while to render them generally available and to describe the procedure involved in their construction.

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### Construction of a Nomogram for Absorption Calculations on Flour Doughs

In the official A. A. C. C. basic baking test (Geddes, 1934), the percentage absorption is computed from the equation:

$$\%\text{ absorption (15\% moisture basis)} = 45.6 + W - (100 - F),$$

where 45.6 represents the cc. of water added per loaf in the form of stock solutions; $W$ is the cc. of additional distilled water added to produce a dough of the desired consistency; and $F$ is the weight of flour required to give 100 g. on a 15% moisture basis (85 g. dry matter).

As the figure 45.6 is a constant, the variables in the equation are percentage absorption, volume of added water (cc.), and the difference $(100 - F)$. Since $(100 - F)$ is related to the flour moisture content, it is more convenient to employ the moisture values directly.

In the construction of the graph, the first step is to draw two parallel lines of such length that the desired scale range can be conveniently covered without making the finest subdivisions unduly small; the distance between these parallel lines should be approximately two-thirds of their length. On one is constructed a scale for moisture, and on the other a scale for water added using accurately measured increments of lengths for each 1% flour moisture and each cubic centimeter of added water. Let these respective lengths be designated as $K_1$ and $K_2$. A third axis is then drawn parallel to and between the axes for flour moisture and added water so located that the distance between it and the flour-moisture and added-water scales respectively is in the same proportion as $K_1$ to $K_2$. On this central axis the absorption scale is constructed. As a starting point, a fixed point on the scale is located by joining any two values on the flour-moisture and added-water scales; the correct absorption for this point is calculated by the equation previously given and designated on the scale. From this reference point the absorption scale is laid out, using unit divisions of the length $\frac{K_1K_2}{K_1 + K_2}$.

In this laboratory the flour is weighed out on a 13.5% moisture basis, and a nomogram for use in computing flour absorptions to this basis is reproduced in Figure 1. The reading of the nomogram is simply accomplished by joining with a straight edge the value for flour moisture with that for the cubic centimeters of water added and reading the corrected absorption from the center scale. A celluloid cursor is very satisfactory for aligning the points. The moisture scale ranges from 10% to 15% in increments of 0.1%, and the added-water scale from 3 to 23 cc. in increments of 0.2 cc. The percentage of

absorption therefore varies from 44 to 70 and the graduations permit of accurate interpolation to 0.1%.

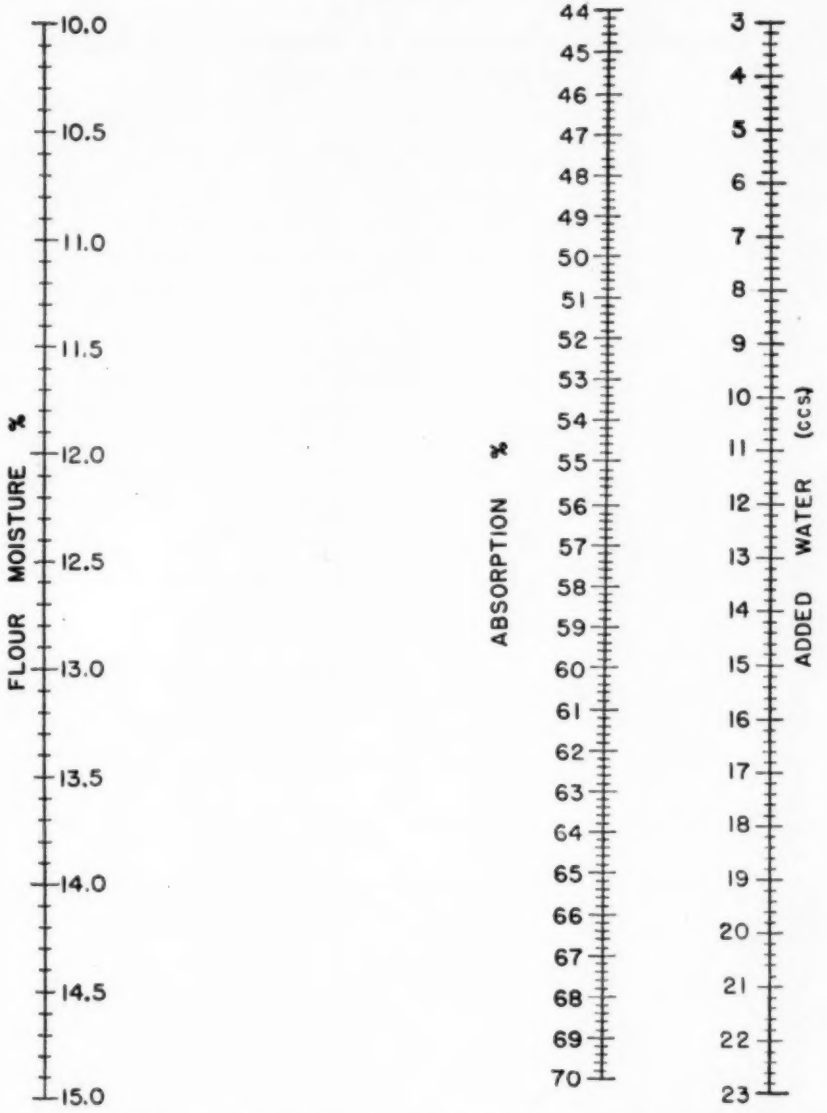


Fig. 1. Nomogram for computing flour absorption to a 13.5% moisture basis, using a flour weight corresponding to 86.5 g. dry matter and the stock solutions specified in the A. A. C. C. baking test.

With the basic baking formula, the nomogram is used as illustrated, but for the malt-phosphate-bromate formula the volume of the stock solutions of these ingredients used per test must be considered as

"added water"; for example, if 14 cc. of distilled water, 1 cc. of malt solution, and 1 cc. of potassium bromate solution were used, the value for "added water" would be 16 cc.

### Construction of a Nomogram for Absorption Calculations on Semolina Water Doughs

The method for experimental macaroni processing as outlined by Fifield (1934) and Binnington and Geddes (1936) calls for a 600-g.

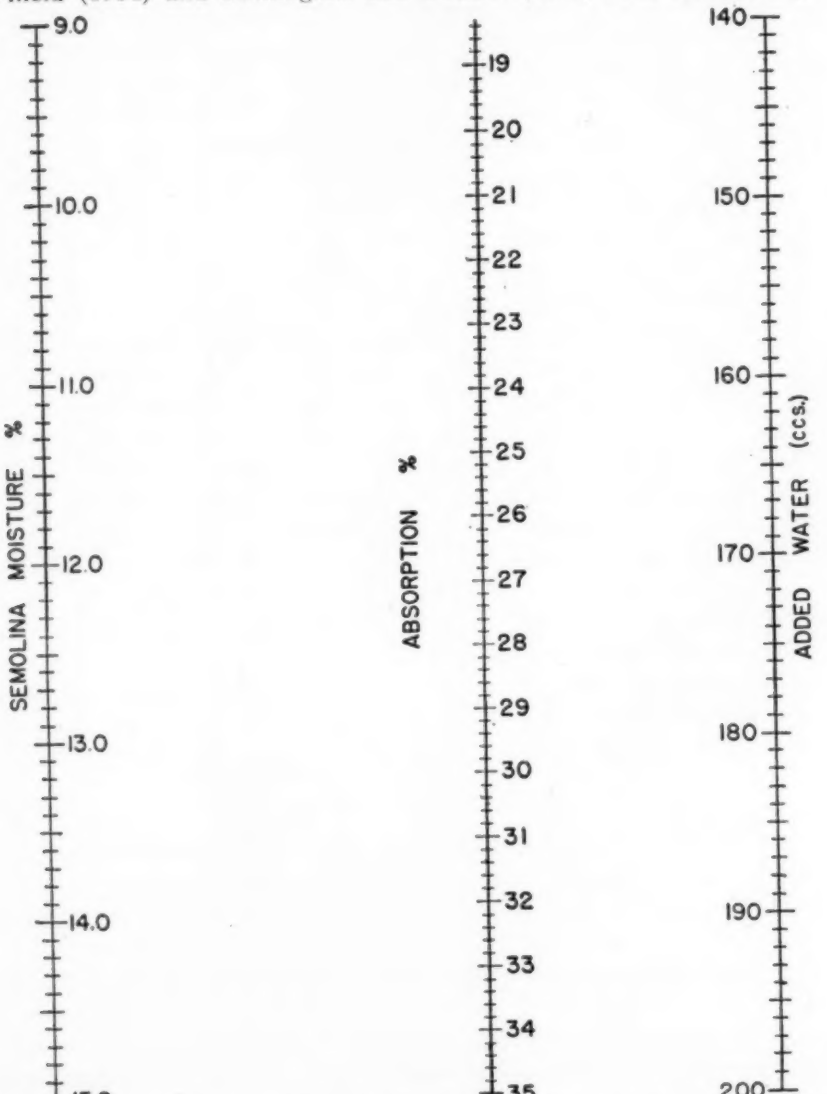


Fig. 2. Nomogram for computing semolina absorption to a 13.5% moisture basis, using a weight of semolina corresponding to 519 g. dry matter (600 g., 13.5% moisture basis).

sample of semolina weighed on a 13.5% moisture basis. Thus the absorption formula becomes:

$$\% \text{ absorption (13.5\% m. b.)} = \frac{\text{cc. added water} - (600 - F)}{600} \times 100,$$

where $F$ is the weight of semolina required to give 600 g. on a 13.5% moisture basis.

Figure 2 shows a nomogram based on this equation. The scales were constructed in the same manner as the previous example. The moisture range is from 9% to 15% in 0.1% increments, the added water scale reading from 140 to 200 cc. in increments of 1 cc., and the percentage absorption from 19 to 35.

## Summary

Nomograms and their method of construction are given for computing flour and semolina absorptions to a 13.5% moisture basis from experimental baking and macaroni test data. The flour-absorption nomogram is based on a flour weight equivalent to 100 g. on a 13.5% moisture basis and the use of stock solutions as prescribed in the A. A. C. C. baking test procedure. The semolina-absorption nomogram is based on a sample weight of 600 g. (13.5% moisture basis).

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# COMPARATIVE METHODS OF MOISTURE DETERMINATION WITH SPECIAL REFERENCE TO THE BRABENDER GRINDER AND OVEN [1]

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One of the interesting developments of recent years has been the manufacture of new types of laboratory apparatus designed to facilitate the routine testing of cereals and their products. The requirements of the grain trade for rapid and convenient methods of estimating moisture have stimulated the manufacture of various types of electrical moisture meters; several efforts have also been made to simplify conventional laboratory air-oven procedures without sacrifice of accuracy, among which is a combined air oven and balance known as the " semi-automatic moisture tester " by the Brabender Corporation, Germany.

The Brabender oven contains a perforated shelf with spaces for ten moisture dishes; this shelf can be rotated by means of a large knob on the top of the oven so that each dish compartment can be brought directly in front of the small oven door. Underneath the oven, and at the front, is a specially constructed balance which is brought into play by drawing down a lever at the side. One arm of the balance has three long prongs which, when the balance is in operation, project into the oven through perforations on the shelf and lift the dish which is in the front position; the balance is fitted with a damping device and comes to rest when the sample and dish are at equilibrium with the counterpoise on the other arm, the percentage of moisture content being read directly on an illuminated scale.

Since all the dishes have the same tare and a fixed sample weight (10 g.) is employed, the moisture content of each sample can be automatically read in turn by rotating the tray without removing the dishes from the oven. Temperature is controlled by a thermo-regulator, and in the early model forced-air circulation was achieved by means of a ventilating fan which was automatically cut off when the balance scale was illuminated.

As an accessory for determining the moisture content of grain, the Brabender Corporation also developed a new type of laboratory grinder, in which attrition is brought about by means of a small grinding cone oscillated within a ring by an electro-magnetic device. Provision is

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made for adjusting the fineness of grind, and the sample passes directly into a glass container placed close to the orifice in order to reduce moisture loss.

The experiments reported in this paper were undertaken to determine the utility of the Brabender grinder and semi-automatic moisture tester in comparison with equipment commonly used on this continent.

## Experimental

The experiments were designed along the lines of those carried out by Cook, Hopkins, and Geddes (1934, 1935) who undertook a comparative study of different grinders and analytical moisture methods in connection with an investigation of the utility and accuracy of several electrical moisture meters. Three grinders, the Brabender electromagnetic, the Hobart, and the Wiley mill were employed and the moisture content of the ground samples determined in the Brabender semi-automatic moisture tester, DeKhotinsky air oven, and the DeKhotinsky vacuum oven. Moistures were also determined by the Brown-Duvel method and by the two-stage drying procedure outlined by Cook *et al.* (1934, 1935).

Twenty half-gallon samples of hard red spring wheat varying in moisture content from approximately 11% to 20% (Brown-Duvel method) were collected and stored in moisture-tight containers for several weeks, in order to ensure reasonable homogeneity with respect to moisture content. These were subdivided into eight subsamples by means of the one-to-eight progressive riffle described by Cook, Hopkins, and Geddes (1934). The subsamples were placed in half-pint double-tight paint cans and allotted at random to the instruments and methods under test. One subsample was assigned to each grinder and from each grind duplicate moisture determinations were made in each of the three ovens.

In their experiments, Cook, Hopkins, and Geddes (1934) found that a significant loss of moisture occurred during the grinding and exposure of the samples during weighing, etc.; they therefore employed a two-stage drying procedure as a basis of reference and also as a means of securing an estimate of the error involved in subsampling (by running duplicate tests on each of two subsamples). These investigators found that a significant error occurred in subsampling and, accordingly, in the present study two of the remaining subsamples were analyzed by this technique.

The Brabender grinder, which produces a relatively coarse meal, tends, like the Hobart, to heat the sample but to a lesser extent. As it grinds very slowly, it was adjusted largely on the basis of the time required. The Hobart mill was set to grind the high-moisture samples

as finely as possible without choking; in the Wiley mill, a 1-mm. sieve was employed. The times required to grind 100 g. wheat with the settings selected were 215 seconds for the Brabender, 30 seconds for the Hobart, and 90 seconds for the Wiley. As an index of the comparative fineness of grinding, the results of sieving tests are recorded in Table I.

The Brabender moisture tester and the DeKhotinsky (size C) air oven were operated at 130° C. and the samples dried for one hour; for the former a 10 (± 0.01) g. sample is weighed into a tared aluminium dish (85 mm. in diameter), and for the latter about 2 g. was accurately weighed into tared aluminium moisture dishes provided with inside fitting covers (as specified by the A.A.C.C.), the covers being entirely removed during drying. The vacuum-oven tests of the three grinds were made on approximately 2-g. samples as outlined in Cereal Laboratory Methods (American Association of Cereal Chemists, 1935), except

TABLE I

RESULTS OF SIEVING TESTS FOR DIFFERENT WHEAT GRINDS

| Grinder | U. S. Standard wire sieves | | | | |
|---|---|---|---|---|---|
| | Percentage over | | | | Percentage through |
| | No. 18 | No. 20 | No. 40 | No. 60 | No. 60 |
| | % | % | % | % | % |
| Brabender electro-magnetic | 68.0 | 10.9 | 13.1 | 4.0 | 4.0 |
| Hobart burr mill | 31.9 | 20.2 | 35.0 | 6.6 | 6.3 |
| Wiley laboratory mill | 13.4 | 23.0 | 48.0 | 8.2 | 7.4 |

that the drying was continued for 16 hours; the covers of the dishes were loosened but not removed during the drying period, and 20 minutes was allowed for releasing the vacuum. In the DeKhotinsky air- and vacuum-oven tests the dishes were allowed to cool for 20 minutes over calcium carbide before weighing.

Single moisture determinations were made on each of two subsamples by the Brown-Duvel tester operated in accordance with the official methods but with certain additional refinements introduced by this laboratory as outlined by Cook *et al.* (1934).

Two further subsamples were used for the two-stage drying method described by these workers. The first stage consisted of drying 100.00 ± 0.01 g. of the wheat for 72 hours at 72° F. and 40% relative humidity in shallow dishes 4″ × 5″, placed in a ventilated cabinet fitted with a screen to exclude dust from the incoming air. At the expiration of this period, all the samples contained about 10.8% moisture and were in approximate equilibrium with the atmosphere. After weighing, the samples were ground in the Hobart burr mill in the same room and duplicate vacuum-oven determinations made on each subsample. The

loss in weight during both stages was then computed in terms of moisture and expressed as a percentage of the original sample.

In addition to the tests on wheat, moisture determinations were conducted on ten samples of flour varying in moisture content from 9.7% to 16.6% (vacuum oven). Duplicate tests were made on 2-g. samples by the official vacuum-oven method and by the 130°C. air-oven method in the Brabender semi-automatic moisture tester and the DeKhotinsky air ovens employing 10-g. and approximately 2-g. samples respectively.

The results are summarized by the statistical constants given in Table II. Appropriate variance analyses were carried out as a measure

TABLE II

STATISTICAL CONSTANTS FOR MOISTURE DATA ON HARD RED SPRING WHEAT SAMPLES

| Method | Means of duplicates | | | | |
|---|---|---|---|---|---|
| | Brown-Duvel method | Brabender grinder | Hobart burr mill | Wiley mill | All grinders |
| | % | % | % | % | % |
| 130°C. air oven | | | | | |
| Brabender oven | — | 14.80 | 14.74 | 14.71 | 14.75 |
| DeKhotinsky oven | — | 14.55 | 14.51 | 14.54 | 14.53 |
| Vacuum oven | — | 15.19 | 15.07 | 15.07 | 15.11 |
| All ovens and methods | — | 14.85 | 14.77 | 14.78 | 14.80 |
| Brown-Duvel method | 14.91 | — | — | — | — |
| Two-stage vacuum oven [1] | | | | | |
| Subsample 1 | — | — | 15.50 | — | — |
| Subsample 2 | — | — | 15.47 | — | — |
| | Mean differences between duplicates | | | | |
| 130°C. air oven | | | | | |
| Brabender oven | — | 0.08 | 0.13 | 0.12 | 0.11 |
| DeKhotinsky oven | — | 0.08 | 0.08 | 0.09 | 0.09 |
| Vacuum oven | — | 0.05 | 0.04 | 0.04 | 0.04 |
| All ovens and methods | | 0.07 | 0.08 | 0.08 | 0.08 |
| Brown-Duvel method | 0.06 | — | — | — | — |
| Two-stage vacuum oven | | | | | |
| Subsample 1 | — | — | 0.06 | — | — |
| Subsample 2 | — | — | 0.03 | — | — |
| | Standard error of duplicates | | | | |
| 130°C. air oven | | | | | |
| Brabender oven | — | 0.08 | 0.13 | 0.11 | 0.11 |
| DeKhotinsky oven | — | 0.07 | 0.07 | 0.09 | 0.08 |
| Vacuum oven | — | 0.05 | 0.04 | 0.04 | 0.04 |
| All ovens and methods | | 0.07 | 0.09 | 0.07 | 0.08 |
| Brown-Duvel method | 0.07 | — | — | — | — |
| Two-stage vacuum oven | — | — | 0.04 | — | — |

[1] Sampling error for two-stage vacuum-oven method is not significant.

of the significance of the differences in the mean values recorded. The difference of 0.03% in the mean moisture content of the two series of subsamples analyzed by the two-stage drying method is not statistically significant, indicating that a negligible error was involved in the subdivision of the samples. It is accordingly valid to compare directly the corresponding moisture values for the different grinders; as determinations were made in the three ovens on each grind, no error in subsampling the whole grain is involved in the oven comparisons for the same grinds. It is noteworthy that, in line with the results of Cook *et al.* (1934), the two-stage vacuum-oven procedure gave higher results than the single-stage vacuum-oven method for the same grind (Hobart), indicating that moisture losses take place in grinding when the moisture in the samples is not at equilibrium with the atmospheric humidity; it seems unlikely that the additional respiration during the preliminary drying could account for the mean difference of 0.42% found.

Considering now the data for the Brabender, Hobart, and Wiley grinds, a much greater variation exists between the various ovens and moisture methods than between grinds. The statistical significance of these variations is shown by the variance analysis given in Table III.

TABLE III

ANALYSIS OF VARIANCE FOR WHEATS—ALL GRINDERS AND OVENS COMBINED

| Variance | D.F. | Variance | F [1] | 5% pt. | F [2] | 5% pt. |
|---|---|---|---|---|---|---|
| Between grinders | 2 | .2014 | — | — | .75 | 3.23 |
| Between ovens | 2 | 10.0932 | — | — | 110.19 | 3.23 |
| Between wheats | 19 | 266.3705 | — | — | 991.33 | 1.85 |
| Interactions | | | | | | |
| Grinders × ovens | 4 | .04445 | 7.04 | 2.42 | — | — |
| Grinders × wheats | 38 | .2687 | 42.58 | 1.45 | — | — |
| Ovens × wheats | 38 | .0916 | 14.51 | 1.45 | — | — |
| Grinders × ovens × wheats | 76 | .04418 | 7.00 | 1.35 | — | — |
| Between duplicates | 180 | .006311 | — | — | — | — |

[1] Variance "between duplicates" used as error.
[2] Variance due to interactions "grinders × wheats" and "ovens × wheats" were used as errors for testing the significance of differences "between grinders," "between wheats," and "between ovens" respectively.

Because of the high significance of the interactions, these rather than duplicate error were used as sources of error in comparing the differences between grinders and between ovens and moisture methods. This analysis shows that the mean values (three ovens, air- and vacuum-oven methods combined) of 14.85%, 14.77%, and 14.78% for the Brabender, Hobart, and Wiley mills, respectively, are not significantly different. However, individual variance analyses for each oven method show that the Brabender grind gives a significantly higher moisture than the Hobart

and Wiley grinds in the instance of the vacuum-oven procedure. It thus appears that the moisture loss through grinding in the Brabender mill tends to be slightly less than in the Hobart or the Wiley mills; this small difference is of little practical importance. The Hobart and Wiley mills have given virtually identical results in this study although Cook *et al.*, in a series involving 150 comparisons, found that the Hobart mill gave slightly higher moisture values but less consistent results from day to day.

The large and significant variance for "between ovens" is due principally to the much higher mean value of 15.11% for the vacuum-oven method than the 130°C. air-oven values of 14.75% and 14.53% for the Brabender and DeKhotinsky ovens respectively. The Brabender semi-automatic moisture tester operated as a 130°C. air oven gave consistently higher moisture values by approximately 0.2% than the DeKhotinsky oven; this result is perhaps surprising, in view of the fact that a 10-g. sample is used in the former and approximately 2 g. in the latter. However, this difference is apparently counteracted by the greater surface area of the Brabender dishes, the use of forced draft, and the elimination of any possibility of moisture gain during weighing. It is of interest to note that the Brown-Duvel method gave a mean moisture content of 14.91%, which is 0.11% higher than the mean for the Brabender grinder and tester.

The experimental error (standard error of duplicates) is 0.04% for the vacuum-oven methods—a value which agrees closely with that of 0.044% reported by Cook *et al.* (1934). This is appreciably lower than the errors of 0.13% and 0.07% for the Brabender and DeKhotinsky air oven procedures for the same grind. For all grinds combined, the experimental errors of 0.11% and 0.08% for these two air ovens are closely similar. Cook *et al.* (1934) obtained standard errors of 0.07% and 0.05% for the DeKhotinsky air-oven determinations on samples ground in the Hobart and Wiley mills respectively. The standard error of 0.07% for the Brown-Duvel method compares favorably with 0.05% found by the above workers in their study involving 300 wheats.

### Results with Flour

The results of moisture tests conducted in the Brabender and DeKhotinsky ovens operated at 130°C. and in the DeKhotinsky vacuum oven (16 hours' drying) on ten flour samples varying in moisture content from 9.7% to 16.6% (vacuum oven) are summarized in Table IV. The two air-oven procedures give closely similar values but they are significantly lower than those furnished by the vacuum-oven method by approximately 0.1%. As in the case of wheats, the vacuum oven has

TABLE IV

STATISTICAL CONSTANTS FOR MOISTURE DATA ON WHEAT FLOURS

| Method | Means of duplicates | Difference between duplicates | |
|---|---|---|---|
| | | Mean | Standard error |
| | % | % | % |
| 130°C. air oven | | | |
| Brabender oven | 11.74 | 0.085 | 0.068 |
| DeKhotinsky oven | 11.78 | 0.059 | 0.052 |
| Vacuum oven | 11.88 | 0.024 | 0.021 |

the lowest experimental error and the Brabender oven slightly the highest. However, the difference between the Brabender and DeKhotinsky errors is not statistically significant. These data indicate that the Brabender semi-automatic moisture tester and the DeKhotinsky oven are quite satisfactory for the A.O.A.C. rapid air-oven method for flour.

## Discussion

While these experiments indicate that the moisture loss due to grinding is essentially similar for the three grinders, their relative placing in this regard would probably differ under other operating conditions. In fact Cook, Hopkins, and Geddes (1934), in studying the suitability of the Hobart and Wiley mills for grinding wheat for the air-oven method found that the Hobart mill gave slightly higher average moisture values than the Wiley, but the standard errors of prediction of vacuum-oven moisture, and of the duplicates, were lower for the latter, showing it to be superior for this determination. In the Wiley mill, those portions of the sample which will pass the sieve escape further reduction and therefore this mill tends to produce a uniform grind at all times. The type of grind obtainable in the Hobart mill is influenced by the setting employed, the moisture content of the sample, and the wear on the burrs; moreover, if many samples are ground in succession, considerable heating occurs. In the present study, only three samples were ground at one session, whereas Cook *et al.* (1934) ground a much larger number. The Brabender grinder will produce a fairly uniform granulation from time to time but yields a relatively coarse meal and is very slow in operation. The times required for the same type of grain for the Hobart, Wiley, and Brabender mills are in the approximate ratio 1 : 3 : 7 respectively. However, the Brabender grinder shows a slightly smaller moisture loss than the other two in the instance of the vacuum-oven procedure.

The Brabender oven technique is much more rapid than the usual

air-oven procedure, since the original weighing of the sample calls for no greater accuracy than ± 0.01 g. and the final weighing is made without transference of the sample from the oven and attendant cooling in a desiccator. The oven accommodates ten samples at a time and while it gives somewhat higher moisture values with wheat than the DeKhotinsky oven when used for the rapid air-oven method, it yields similar values for flour.

## Summary

The Brabender electro-magnetic grinder and semi-automatic moisture tester have been compared with the Hobart and Wiley grinders and the DeKhotinsky air and vacuum ovens in determining the moisture content of 20 samples of wheat varying in moisture content from approximately 11% to 20% and 10 samples of flour containing from approximately 10% to 17% moisture. Determinations were also made by the Brown-Duvel method and a two-stage vacuum-oven procedure, in which the samples were brought to approximate equilibrium with atmospheric humidity before grinding.

The moisture loss during grinding was essentially the same for the three grinders, although the Brabender device tended to give slightly higher moisture values. It is seven times slower than the Hobart and two and one-half times slower than the Wiley, and gives a relatively coarse grind.

In the wheat tests, the two-stage vacuum-oven procedure gave a mean moisture value 0.4% higher than the single-stage method, which was in turn approximately 0.5% higher than for the A.O.A.C. 130°C. air-oven method. The Brown-Duvel method gave a mean value 0.1% higher than the one-stage vacuum-oven technique. The Brabender semi-automatic moisture tester, operated as a 130°C. air oven, gave higher values than the DeKhotinsky oven by approximately 0.2%. The standard error of duplicate determinations was 0.04% for the two vacuum-oven procedures, which is appreciably lower than the standard errors by all grinds of 0.11% and 0.08% for the Brabender and DeKhotinsky air ovens respectively. The Brabender oven technique is more rapid and convenient.

The Brabender and DeKhotinsky ovens, using the 130°C. air-oven methods, gave similar mean values for moisture in flour, which were 0.1% lower than the vacuum-oven moisture. The standard error of duplicates was 0.02% for the vacuum oven, 0.05% for the DeKhotinsky, and 0.07% for the Brabender.

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# BARLEY AND MALT STUDIES. V. EXPERIMENTAL MALTING OF BARLEYS GROWN IN 1937[1]

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The regional investigations on the malting quality of barleys are given in detail for the five standard varieties grown in 1937. The descriptions and the detailed data on the five standard varieties for the three previous years were given before the association in 1937.[2] The present paper therefore represents a progress report on the malting controls and the malts from the five barley varieties for the fourth year of the investigations.

## Growing Conditions During the Season of 1937

Climatic conditions were relatively favorable for barley development during the early part of the growing season. The epidemic of stem rust on barley developed early enough at many of the stations, however, to cause severe damage in quality. This was especially true at DeKalb, Ill., Madison Wis., Kanawha, Ia., Lincoln, Neb., and Brookings, S. D. In contrast the barleys from Urbana, Ill., and Waseca, Minn., were better than in the previous season. The barleys from the stations farther west, Bozeman, Mont., Fort Collins and Fort Lewis, Colo. (where the barleys were irrigated), and Davis, Cal., were grown under climatic conditions generally similar to the previous seasons and were not damaged by stem rust.

[1] Based on cooperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Wisconsin Agricultural Experiment Station and other states cooperating in the Barley Improvement Council. The federal WPA has contributed to the research through the University of Wisconsin WPA Natural Science Project. The United States Maltsters Association has helped in the investigations through an Industrial Fellowship Research grant to the University of Wisconsin.

[2] J. G. Dickson, A. D. Dickson, H. L. Shands, and B. A. Burkhart, Barley and malt studies: IV Experimental malting of barleys grown in 1936 and summary data for three years 1934, 1935, and 1936, Cereal Chem. **15**: 133–168, 1938.

### Study of Malting Controls

Two malting controls were used in the routine malting of the barleys grown in 1937. Wisconsin Barbless (Wisconsin Pedigree 38) barley No. 726, grown at Manitowoc in 1937, was used in all eight series, and Oderbrucker (Wisconsin Pedigree 5-1) barley No. 464, grown at Madison in 1936, was used with six of the series of barleys malted and analyzed. The means for the series of runs in the malting chamber together with the standard deviations and coefficients of variability are given in Table I.

The malting chamber was operated with more uniform temperature and humidity control than in the three previous seasons. Temperature adjustment was also improved in the drying process. In addition better equipment was available for weighing the bulk malts. A combination of these conditions resulted in less variability in 1937 than in previous years. The eight runs of the Wisconsin Barbless control had less variability for moisture content of green and dried malt, recovery of malt from barley, soluble nitrogen in the wort, and diastatic power. The variability in kernel weight, extract, and nitrogen was greater than in 1936 and fluctuated about the average for the previous years. The six runs of the Oderbrucker control showed a greater variability than the Wisconsin Barbless control except for kernel weight, moisture content of green malt, and malt nitrogen. Compared with the previous year there was less variability in kernel weight, total nitrogen, and diastatic power and greater variability in extract and soluble nitrogen in the 1937 series of Oderbrucker controls. The data given in Table I show the need of further improvement in controlling variation in the moisture content of the dried malt, which in turn should further reduce the fluctuations in diastatic power of malts having high diastase. The variation in the total nitrogen content has not been reduced by the use of the Wiley mill in grinding the samples.

The use of the same Oderbrucker control as in 1936 gives an interesting comparison of the average composition of the malts from a barley malted the same year as grown and carried over in storage one year and then malted. The barley was steeped and malted at approximately the same moisture content during the two seasons. It was steeped to an average moisture content of 46.3% in 1936 and 45.9% in 1937. The average moisture content at the end of the germination period was 45.4% in 1936 and 44.7% in 1937. The average moisture content of the dried malts was somewhat lower in 1936, 4.8% in contrast to 5.5% in 1937. Recovery of malt from barley, expressed on the dry basis, was 89.5% in 1936 and 89.0% in 1937. The kernel weight

TABLE I

VARIABILITY OF MALTING CONTROLS USED IN EACH MALTING SERIES IN THE LARGE UNIT IN 1937–1938

| Calculations | Moisture content reached in steep | Moisture content green malt | Moisture content dried malt | Recovery of malt from barley, dry basis | Kernel weight of malt, dry basis | Extract yield of malt, dry basis | Total nitrogen in malt | Soluble nitrogen in wort | Diastatic power of malt |
|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | *mg.* | % | % | % | ° *L.* |
| *8 Series* Wisconsin Barbless (Ped. 38) | | | | | | | | | |
| Mean | 45.9 | 44.5 | 5.5 | 89.8 | 23.0 | 71.0 | 2.15 | 0.573 | 126.9 |
| Standard deviation | 0.410 | 0.517 | 0.591 | 0.866 | 0.524 | 0.363 | 0.075 | 0.011 | 4.520 |
| 5% point | 0.9 | 1.2 | 1.4 | 2.0 | 1.2 | 0.8 | 0.2 | 0.3 | 10.4 |
| Coefficient of variability | 0.89 | 1.16 | 10.72 | 0.96 | 2.27 | 0.51 | 3.51 | 1.97 | 3.56 |
| *6 Series* Oderbrucker (Ped. 5–1) | | | | | | | | | |
| Mean | 45.9 | 44.7 | 5.5 | 89.0 | 22.7 | 74.8 | 2.11 | 0.823 | 146.3 |
| Standard deviation | 0.587 | 0.517 | 0.600 | 0.902 | 0.366 | 0.535 | 0.063 | 0.032 | 9.065 |
| 5% point | 1.4 | 1.2 | 1.5 | 2.2 | 0.9 | 1.3 | 0.2 | 0.1 | 22.2 |
| Coefficient of variability | 1.28 | 1.16 | 11.00 | 1.01 | 1.61 | 0.71 | 2.99 | 3.89 | 6.19 |

of the malt was higher in 1936, 23.7 mg. in contrast to 22.7 mg. in 1937. Extract content, expressed on the dry basis, was 1.1% lower in 1936, that is 73.7% in 1936 and 74.8% in 1937. There was no significant difference in total nitrogen content of the two seasons' malts, although the average soluble nitrogen in the wort was appreciably lower in 1936, 0.674% in contrast to 0.823% nitrogen in 1937. The diastatic power of the malts for the two years was the same, 146.3 in 1936 and 146.6 in 1937. The results with this one lot of barley suggest that storage for one year may increase the extract yield slightly and may result in a significant increase in the soluble nitrogen in the wort, at least with the laboratory mashing procedure.

### Study of Malts from the Barleys Grown in 1937

Fourteen stations furnished barley of the five standard varieties grown in 1937. The quality of the barleys from DeKalb, Ill., Madison, Wis., Kanawha, Ia., Brookings, S. D., and Lincoln, Neb., was comparatively poor. Bushel weight and kernel weight were low and the percentage of shriveled kernels high. The barleys from Urbana, Ill., Ames, Ia., and Waseca, Minn., were about average quality. The grain from the western stations was very similar in quality to that of the previous years (Table II).

The barleys were malted approximately the same as in the previous years. The moisture content of the barley after steeping and during the germination period was lowered somewhat in contrast with the previous year except for the Oderbrucker, which was about the same as in 1936. The barleys were steeped to 46% moisture and malted at 46% to 44% moisture content.

As might be expected from the previous discussion of the barleys, there was a wide range in physical and chemical characters in the barleys and malts from the various locations. This makes it advisable to present the data for the individual stations as well as the average for all fourteen stations (Table II).

The yield in bushels per acre varied greatly, depending in large part upon the date and severity of the stem rust attack in the north-central barley area. The yields at Urbana, Illinois, Ames, Iowa, Waseca, Minnesota, and Fargo, North Dakota, were fairly representative of good barley yields in the spring barley area. Stem rust at these stations either was not severe or it developed too late to influence greatly the yield or quality of the grain. In contrast to the barley grown at these stations, that grown at East Lansing, Michigan, DeKalb, Illinois, Madison, Wisconsin, Kanawha, Iowa and Brookings, South Dakota, was very low in acre yield and below average in the general quality of

## TABLE II

PHYSICAL AND CHEMICAL FACTORS OF BARLEYS AND MALTS FOR THE FIVE STANDARD VARIETIES GROWN IN THE REGIONAL SERIES IN 1937

| Location and variety | Yield barley per acre | Bushel wt. barley, dry basis | Kernel wt. barley, dry basis | Total protein barley, N × 6.25 | Ash content barley | Wt. of hull of barley | Est. time steeped to reach 46% moist | Moisture content steeped barley | Moisture content green malt | Recovery malt from barley, dry basis | Bushel wt. of malt, 4% basis | Kernel wt. of malt, dry basis | Moisture content malt | Extract fine grind, dry basis | Time of conversion | Diastatic power | Total nitrogen malt | Total protein malt N × 6.25 | Soluble nitrogen in wort | Wort nitrogen relation malt N | Perm. soluble N relation malt N | Formol nitrogen relation malt N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *bu.* | *lbs.* | *mg.* | % | % | % | *hrs.* | % | % | % | *lbs.* | *mg.* | % | % | *min.* | ° *L.* | % | % | % | % | % | % |
| *Oderbrucker (Ped. 3–1)* | | | | | | | | | | | | | | | | | | | | | | |
| East Lansing, Mich. | 20.2 | 35.4 | 24.5 | 11.32 | 3.05 | 15.6 | 41 | 46.0 | 45.6 | 88.9 | 32.3 | 22.2 | 4.9 | 73.1 | 7–10 | 128 | 1.88 | 11.76 | .702 | 37.3 | 36.2 | 6.54 |
| Urbana, Ill. | 43.7 | 41.3 | 27.5 | 15.56 | — | 15.5 | 38 | 43.2 | 44.6 | 89.7 | 36.0 | 24.9 | 4.9 | 75.1 | 7 | 162 | 2.07 | 12.89 | .716 | 34.6 | 33.7 | 6.57 |
| DeKalb, Ill. | 16.3 | 38.9 | 25.2 | 13.06 | 3.15 | 14.2 | 30 | 47.1 | 44.6 | 89.5 | 33.5 | 22.3 | 4.7 | 72.1 | 5 | 147 | 2.16 | 13.50 | .695 | 32.2 | 30.6 | 5.88 |
| Madison, Wis. | 17.5 | 28.9 | 18.0 | 13.25 | 3.47 | 22.2 | 12 | 49.5 | 44.9 | 88.8 | 27.2 | 16.4 | 4.6 | 66.5 | 25 | 134 | 2.13 | 13.32 | .712 | 33.4 | 32.8 | 6.53 |
| Waseca, Minn. | 38.3 | 41.8 | 26.1 | 11.81 | 3.43 | 15.2 | 38 | 46.4 | 45.8 | 87.7 | 34.9 | 21.4 | 5.8 | 74.5 | 5–7 | 168 | 1.90 | 11.90 | .693 | 36.5 | 35.2 | 6.63 |
| Kanawha, Ia. | 4.2 | 30.5 | 19.6 | 13.79 | 3.80 | 18.5 | 14 | 53.0 | 52.0 | 84.1 | 28.0 | 17.3 | 5.0 | 69.4 | 5 | 215 | 2.19 | 13.67 | .867 | 39.6 | 38.4 | 7.85 |
| Ames, Ia. | — | 36.5 | 19.2 | 16.06 | 3.36 | 16.0 | 17 | 48.4 | 45.3 | 88.7 | 31.1 | 17.5 | 4.5 | 71.3 | 5 | 208 | 2.66 | 16.62 | .976 | 36.7 | 36.0 | 7.03 |
| Fargo, N. D. | 28.3 | 37.0 | 21.0 | 15.81 | 3.11 | 17.4 | 13 | 50.4 | 53.3 | 83.2 | 27.0 | 17.1 | 5.1 | 70.3 | 5 | 212 | 2.73 | 17.06 | 1.210 | 44.3 | 42.1 | 9.60 |
| Brookings, S. D. | 2.3 | 34.0 | 19.2 | 21.06 | 3.24 | 17.8 | 16 | 53.4 | 43.6 | 92.4 | 31.4 | 17.5 | 6.0 | 66.9 | <5 | 333 | 3.56 | 22.25 | 1.090 | 30.6 | 28.7 | — |
| Lincoln, Neb. | 10.3 | 36.7 | 17.4 | 19.12 | 3.71 | 19.8 | 14 | 46.9 | 44.1 | 89.9 | 33.0 | 15.5 | 5.9 | 65.9 | <5 | 252 | 3.15 | 19.68 | 1.060 | 33.7 | 31.4 | — |
| Bozeman, Mont. | 55.6 | 47.4 | 36.1 | 19.50 | 2.87 | 9.6 | 38 | 45.6 | 45.5 | 87.7 | 38.8 | 30.5 | 5.7 | 74.3 | 5 | 227 | 2.71 | 16.94 | .765 | 28.2 | 26.1 | 4.76 |
| Fort Collins, Colo. | — | 44.9 | 30.6 | 15.37 | 2.65 | 9.6 | 36 | 46.2 | 45.6 | 88.2 | 37.5 | 28.2 | 5.7 | 74.4 | 5 | 210 | 2.60 | 16.25 | .785 | 30.2 | 28.4 | 5.54 |
| Fort Lewis, Colo. | 45.0 | 46.9 | 31.8 | 10.94 | 3.10 | 10.9 | 41 | 46.2 | 45.3 | 89.6 | 39.4 | 29.0 | 5.5 | 76.0 | 7 | 142 | 1.85 | 11.58 | .567 | 30.6 | 28.1 | 4.37 |
| Davis, Calif. | 11.1 | 45.0 | 35.5 | 12.34 | 3.00 | 10.5 | 68 | 43.9 | 43.9 | 90.2 | 40.5 | 31.8 | 5.5 | 76.4 | 7–10 | 167 | 2.05 | 12.83 | .687 | 33.4 | 31.2 | 6.05 |
| Average | 24.40 | 38.6 | 25.8 | 14.93 | 3.23 | 15.2 | 26 | 47.6 | 46.0 | 88.5 | 33.6 | 22.3 | 5.3 | 71.9 | 7 | 193.2 | 2.40 | 15.01 | .823 | 34.4 | 32.8 | 6.44 |
| *Wisconsin Barbless (Ped. 38)* | | | | | | | | | | | | | | | | | | | | | | |
| East Lansing, Mich. | 25.1 | 36.6 | 27.2 | 12.40 | 3.02 | 13.5 | 32 | 47.3 | 44.4 | 89.3 | 33.3 | 24.7 | 5.9 | 71.4 | 10 | 125 | 1.99 | 12.45 | .638 | 32.1 | 31.0 | 5.98 |
| Urbana, Ill. | 52.1 | 38.1 | 25.3 | 13.25 | 3.18 | 16.9 | 27 | 46.3 | 43.8 | 88.7 | 32.4 | 22.8 | 5.0 | 70.9 | 5 | 124 | 2.21 | 13.79 | .659 | 29.8 | 28.2 | 5.57 |
| DeKalb, Ill. | 23.4 | 36.9 | 23.0 | 12.45 | 3.35 | 15.9 | 19 | 47.0 | 44.7 | 89.7 | 31.3 | 20.0 | 4.5 | 71.4 | 5–7 | 146 | 2.06 | 12.89 | .733 | 35.6 | 33.3 | 6.84 |
| Madison, Wis. | 26.6 | 30.2 | 22.3 | 11.81 | 3.17 | 18.1 | 16 | 48.9 | 43.3 | 90.8 | 30.3 | 20.4 | 5.3 | 68.1 | 20–25 | 74 | 1.90 | 11.90 | .538 | 28.3 | 26.7 | 4.89 |
| Waseca, Minn. | 57.1 | 43.5 | 28.6 | 12.25 | 3.15 | 14.1 | 49 | 45.8 | 45.2 | 88.4 | 36.6 | 25.4 | 5.2 | 74.1 | 10 | 119 | 1.87 | 11.70 | .591 | 31.6 | 30.3 | 5.24 |
| Kanawha, Ia. | 31.6 | 36.6 | 24.3 | 13.25 | 3.19 | 16.9 | 36 | 47.3 | 44.2 | 90.0 | 34.8 | 21.4 | 5.1 | 70.4 | 10–15 | 117 | 2.07 | 12.95 | .624 | 30.1 | 29.5 | 5.02 |
| Ames, Ia. | 47.8 | 38.7 | 24.6 | 15.25 | 3.06 | 14.3 | 49 | 45.6 | 44.7 | 89.7 | 34.4 | 22.7 | 5.1 | 70.0 | 7–10 | 144 | 2.53 | 15.81 | .707 | 27.9 | 27.2 | 4.27 |
| Fargo, N. D. | 48.1 | 37.9 | 23.3 | 13.93 | 2.84 | 17.7 | 28 | 48.0 | 45.4 | 89.7 | 32.3 | 21.0 | 5.4 | 68.5 | 10 | 144 | 2.28 | 14.25 | .596 | 26.1 | 25.4 | 4.69 |
| Brookings, S. D. | 11.2 | 32.4 | 18.1 | 18.86 | 3.15 | 20.0 | 13 | 46.4 | 44.4 | 90.4 | 29.3 | 17.0 | 5.4 | 63.8 | 7–10 | 203 | 3.19 | 19.94 | .845 | 26.5 | 24.8 | — |
| Lincoln, Neb. | 26.7 | 35.3 | 22.2 | 17.12 | 3.23 | 18.9 | 25 | 47.3 | 43.9 | 90.3 | 31.9 | 19.1 | 6.2 | 66.6 | 10 | 155 | 2.74 | 17.12 | .823 | 30.0 | 27.7 | — |
| Bozeman, Mont. | 70.4 | 47.3 | 35.3 | 17.93 | 2.72 | 10.8 | 47 | 46.2 | 44.3 | 88.6 | 39.5 | 32.1 | 6.2 | 74.2 | 7–10 | 145 | 2.35 | 14.67 | .539 | 22.9 | 21.9 | 3.32 |
| Fort Collins, Colo. | 48.6 | 43.8 | 28.8 | 14.61 | 2.68 | 10.8 | 53 | 46.0 | 44.4 | 89.1 | 36.8 | 27.1 | 5.8 | 73.0 | 5 | 144 | 2.43 | 15.19 | .628 | 25.8 | 25.1 | 3.99 |
| Fort Lewis, Colo. | 37.0 | 41.8 | 28.1 | 9.63 | 3.11 | 11.2 | 45 | 46.4 | 44.7 | 90.6 | 38.2 | 26.0 | 5.8 | 73.0 | 20 | 74 | 1.58 | 9.89 | .401 | 25.4 | 24.4 | 3.04 |
| Davis, Calif. | 41.6 | 43.3 | 36.1 | 11.20 | 3.00 | 13.6 | 66 | 46.2 | 43.3 | 90.6 | 38.9 | 33.1 | 5.3 | 74.6 | 10–15 | 100 | 1.82 | 11.38 | .530 | 29.1 | 28.3 | 5.33 |
| Average | 39.09 | 38.7 | 26.2 | 13.85 | 3.06 | 15.2 | 38 | 46.7 | 44.3 | 89.6 | 34.3 | 23.8 | 5.4 | 70.7 | 10.5 | 129.6 | 2.21 | 13.85 | .632 | 28.6 | 27.4 | 4.85 |
| *Velvet (Minn. 447)* | | | | | | | | | | | | | | | | | | | | | | |
| East Lansing, Mich. | 27.8 | 37.1 | 24.9 | 11.52 | 3.07 | 15.5 | 32 | 48.3 | 44.3 | 88.7 | 33.1 | 21.4 | 4.7 | 72.9 | 7–10 | 118 | 1.93 | 12.08 | .716 | 37.1 | 35.6 | 6.32 |
| Urbana, Ill. | 45.6 | 41.7 | 27.4 | 13.67 | 2.96 | 13.5 | 39 | 43.4 | 44.3 | 89.7 | 36.2 | 25.1 | 5.2 | 74.7 | 7 | 158 | 2.23 | 13.93 | .768 | 34.4 | 33.2 | 6.64 |

TABLE II– *Continued*

TABLE II– *Continued*

| | *bu.* | *lbs.* | *mg.* | % | % | % | *hrs.* | % | % | % | *lbs.* | *mg.* | % | % | *min.* | ° *L.* | % | % | % | % | % | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Velvet (Minn. 447)—Cont.* | | | | | | | | | | | | | | | | | | | | | | |
| DeKalb, Ill. | 17.0 | 37.4 | 23.6 | 12.83 | 3.47 | 15.8 | 23 | 46.6 | 44.1 | 88.1 | 30.3 | 19.4 | 4.8 | 70.1 | 10 | 149 | 2.18 | 13.62 | .814 | 37.3 | 36.0 | 7.30 |
| Madison, Wis. | 19.5 | 31.1 | 19.9 | 12.51 | 3.38 | 19.6 | 16 | 49.6 | 43.7 | 89.4 | 29.2 | 17.5 | 5.0 | 68.3 | 5–7 | 106 | 1.95 | 12.19 | .703 | 36.1 | 34.8 | 7.08 |
| Waseca, Minn. | 44.6 | 43.1 | 25.1 | 11.90 | 3.39 | 14.5 | 46 | 46.8 | 45.2 | 88.5 | 35.6 | 22.0 | 5.4 | 75.6 | 7–10 | 128 | 1.83 | 11.46 | .690 | 37.7 | 37.0 | 7.05 |
| Kanawha, Ia. | 20.3 | 34.1 | 21.5 | 12.89 | 3.97 | 18.3 | 26 | 48.3 | 45.3 | 88.7 | 33.1 | 19.5 | 4.7 | 70.5 | 5–7 | 135 | 2.02 | 12.63 | .750 | 37.1 | 36.3 | 6.39 |
| Ames, Ia. | 42.0 | 36.5 | 20.3 | 15.59 | 3.25 | 17.3 | 27 | 48.2 | 45.6 | 88.6 | 32.0 | 18.1 | 4.4 | 69.7 | 10–15 | 196 | 2.51 | 15.69 | .824 | 32.8 | 31.2 | 5.66 |
| Fargo, N. D. | 42.4 | 37.1 | 23.6 | 13.99 | 3.04 | 16.0 | 20 | 48.8 | 45.7 | 88.7 | 32.1 | 20.3 | 5.3 | 69.9 | 7 | 171 | 2.35 | 14.67 | .797 | 33.9 | 32.4 | 6.77 |
| Brookings, S. D. | 10.4 | 33.8 | 18.1 | 16.62 | 3.30 | 19.9 | 16 | 45.8 | 44.4 | 90.1 | 31.7 | 16.6 | 5.9 | 67.0 | <5 | 214 | 2.77 | 17.30 | 1.040 | 37.5 | 35.7 | — |
| Lincoln, Neb. | 17.7 | 36.2 | 20.4 | 18.24 | 3.47 | 18.4 | 20 | 47.0 | 44.8 | 89.9 | 32.6 | 17.8 | 6.2 | 68.3 | 7 | 224 | 2.92 | 18.24 | 1.080 | 37.0 | 34.6 | — |
| Bozeman, Mont. | 76.2 | 46.0 | 34.2 | 17.86 | 2.83 | 12.0 | 46 | 46.2 | 44.1 | 88.9 | 38.9 | 30.7 | 6.0 | 73.7 | 5 | 154 | 2.33 | 14.55 | .574 | 24.6 | 23.2 | 3.78 |
| Fort Collins, Colo. | 31.7 | 43.0 | 30.4 | 16.12 | 2.91 | 11.5 | 37 | 46.8 | 45.7 | 87.9 | 35.0 | 26.6 | 6.0 | 74.2 | 5–7 | 185 | 2.55 | 15.93 | .828 | 32.5 | 30.4 | 5.80 |
| Fort Lewis, Colo. | 24.7 | 44.8 | 30.6 | 10.88 | 3.05 | 11.7 | 38 | 46.4 | 45.0 | 88.4 | 37.0 | 27.0 | 5.7 | 76.1 | 7–10 | 129 | 1.79 | 11.20 | .594 | 33.2 | 30.7 | 5.59 |
| Davis, Calif. | 16.4 | 46.0 | 33.3 | 12.13 | 2.91 | 10.2 | 53 | 45.8 | 44.1 | 90.1 | 39.0 | 29.5 | 5.3 | 76.7 | 7–10 | 129 | 1.95 | 12.19 | .670 | 34.4 | 31.8 | 6.62 |
| Average | 31.16 | 39.1 | 25.2 | 14.05 | 3.21 | 15.3 | 27 | 47.0 | 44.7 | 88.9 | 34.0 | 22.3 | 5.3 | 72.0 | 7.5 | 153.3 | 2.23 | 13.76 | .775 | 34.7 | 33.1 | 6.29 |
| *Manchuria (N. D. 2121)* | | | | | | | | | | | | | | | | | | | | | | |
| East Lansing, Mich. | 16.6 | 35.9 | 24.0 | 12.40 | 3.19 | 15.1 | 23 | 49.4 | 44.7 | 89.0 | 31.8 | 21.9 | 6.1 | 74.7 | 7 | 178 | 2.09 | 13.06 | .868 | 41.5 | 39.5 | 8.52 |
| Urbana, Ill. | 41.6 | 41.2 | 27.2 | 13.62 | 3.17 | 12.9 | 32 | 43.8 | 44.4 | 89.5 | 35.2 | 22.7 | 5.4 | 75.1 | 5 | 166 | 2.24 | 13.99 | .762 | 34.0 | 32.5 | 6.34 |
| DeKalb, Ill. | 16.3 | 37.3 | 21.3 | 13.38 | 3.50 | 13.8 | 18 | 47.2 | 45.9 | 88.4 | 30.6 | 19.5 | 5.1 | 71.9 | 10 | 174 | 2.29 | 14.31 | .850 | 37.1 | 35.5 | 7.69 |
| Madison, Wis. | 14.8 | 27.9 | 17.3 | 13.50 | 3.50 | 20.8 | 10 | 49.5 | 45.0 | 89.4 | 27.1 | 15.3 | 4.5 | 67.3 | 10 | 141 | 2.08 | 13.00 | .773 | 37.2 | 35.9 | 7.31 |
| Waseca, Minn. | 47.7 | 42.0 | 25.2 | 13.00 | 3.33 | 13.9 | 34 | 46.1 | 45.6 | 88.4 | 35.5 | 24.6 | 6.3 | 75.3 | 7–10 | 179 | 2.17 | 13.56 | .801 | 36.9 | 35.1 | 7.10 |
| Kanawha, Ia. | 11.3 | 31.0 | 20.0 | 14.05 | 4.01 | 14.7 | 19 | 49.9 | 43.8 | 89.1 | 31.3 | 17.0 | 4.5 | 70.4 | 7–10 | 187 | 2.28 | 14.25 | .842 | 36.9 | 37.1 | 5.44 |
| Ames, Ia. | — | 36.2 | 20.6 | 16.55 | 3.34 | 14.0 | 23 | 48.6 | 45.4 | 89.2 | 32.4 | 22.6 | 4.5 | 71.4 | 5 | 201 | 2.66 | 16.62 | .919 | 34.5 | 33.2 | 6.62 |
| Fargo, N. D. | 34.9 | 36.7 | 22.0 | 14.18 | 2.97 | 16.4 | 19 | 48.4 | 53.0 | 83.8 | 28.1 | 18.6 | 5.4 | 69.8 | 5 | 184 | 2.36 | 14.73 | .892 | 37.8 | 36.1 | 8.05 |
| Brookings, S. D. | 3.7 | 33.7 | 18.7 | 19.86 | 3.30 | 15.9 | 12 | 47.3 | 43.7 | 91.1 | 30.5 | 17.6 | 6.2 | 68.3 | 5 | 342 | 3.18 | 19.86 | 1.050 | 33.0 | 31.4 | — |
| Lincoln, Neb. | 13.2 | 35.0 | 18.3 | 18.86 | 3.62 | 17.3 | 17 | 46.3 | 44.8 | 89.8 | 31.4 | 16.5 | 6.2 | 69.0 | 7 | 283 | 3.02 | 18.86 | 1.080 | 35.8 | 33.0 | — |
| Bozeman, Mont. | 69.6 | 46.9 | 34.7 | 15.68 | 2.93 | 8.9 | 45 | 44.9 | 44.9 | 87.7 | 39.2 | 30.3 | 6.0 | 75.3 | 5 | 211 | 2.73 | 17.06 | .786 | 28.8 | 27.7 | 4.98 |
| Fort Collins, Colo. | 36.5 | 41.7 | 26.9 | 15.86 | 2.93 | 10.4 | 35 | 46.8 | 45.9 | 87.7 | 34.5 | 23.2 | 5.8 | 73.9 | 5 | 210 | 2.56 | 16.00 | .834 | 32.6 | 31.2 | 6.13 |
| Fort Lewis, Colo. | 25.0 | 45.8 | 28.2 | 11.76 | 3.09 | 10.5 | 37 | 46.9 | 45.1 | 88.8 | 38.6 | 26.3 | 5.6 | 75.9 | 5 | 144 | 1.90 | 11.90 | .631 | 33.2 | 30.6 | 5.53 |
| Davis, Calif. | 15.6 | 44.5 | 34.9 | 11.64 | 2.91 | 11.9 | 57 | 45.5 | 43.7 | 89.3 | 39.6 | 30.1 | 5.4 | 76.9 | 7–10 | 152 | 1.90 | 11.90 | .688 | 36.2 | 34.1 | 7.11 |
| Average | 26.68 | 38.3 | 24.2 | 14.59 | 3.06 | 14.0 | 23 | 47.2 | 45.4 | 88.7 | 33.2 | 21.9 | 5.5 | 72.5 | 6.7 | 196.6 | 2.39 | 14.94 | .841 | 35.2 | 33.8 | 6.73 |
| *Trebi* | | | | | | | | | | | | | | | | | | | | | | |
| East Lansing, Mich. | 30.6 | 35.2 | 34.2 | 11.14 | 2.89 | 15.8 | 32 | 49.0 | 44.0 | 90.5 | 33.0 | 32.8 | 5.6 | 74.5 | 10–15 | 125 | 1.86 | 11.64 | .663 | 35.6 | 33.6 | 6.94 |
| Urbana, Ill. | 54.3 | 41.8 | 36.7 | 12.34 | 2.71 | 12.8 | 49 | 43.7 | 44.0 | 90.0 | 36.8 | 33.3 | 5.6 | 76.3 | 7–10 | 136 | 2.06 | 12.89 | .613 | 29.8 | 28.6 | 5.49 |
| DeKalb, Ill. | 32.1 | 38.7 | 29.6 | 13.93 | 3.16 | 14.8 | 34 | 46.6 | 45.0 | 89.4 | 32.7 | 28.0 | 5.2 | 71.8 | 5 | 143 | 2.30 | 14.36 | .683 | 29.7 | 26.9 | 5.35 |
| Madison, Wis. | 26.7 | 32.4 | 31.3 | 12.08 | 3.02 | 19.0 | 33 | 47.3 | 41.1 | 92.5 | 32.7 | 29.2 | 5.5 | 70.5 | 20–25 | 105 | 1.99 | 12.45 | .552 | 27.7 | 26.3 | 4.67 |
| Waseca, Minn. | 67.3 | 42.0 | 35.1 | 11.46 | 3.11 | 14.0 | 61 | 45.1 | 44.4 | 89.8 | 35.8 | 31.7 | 5.7 | 75.6 | 15–20 | 146 | 1.86 | 11.64 | .585 | 31.5 | 28.7 | 5.05 |
| Kanawha, Ia. | 28.1 | 36.1 | 31.5 | 13.38 | 3.43 | 15.1 | 42 | 47.7 | 44.1 | 90.6 | 34.2 | 28.7 | 5.2 | 72.4 | 10–15 | 168 | 2.21 | 13.79 | .667 | 30.2 | 28.2 | 4.93 |
| Ames, Ia. | 43.5 | 37.7 | 29.4 | 15.81 | 2.81 | 14.4 | 35 | 48.2 | 44.9 | 89.5 | 33.8 | 27.5 | 5.4 | 71.7 | 7–10 | 187 | 2.19 | 13.67 | .728 | 33.2 | 30.8 | 4.93 |
| Fargo, N. D. | 47.2 | 36.0 | 29.6 | 14.87 | 2.95 | 15.6 | 29 | 48.0 | 45.2 | 89.5 | 32.2 | 26.5 | 5.4 | 68.4 | 7 | 168 | 2.48 | 15.50 | .690 | 27.9 | 25.8 | 4.76 |
| Brookings, S. D. | 17.0 | 31.7 | 24.1 | 17.74 | 3.19 | 19.7 | 19 | 48.5 | 45.4 | 89.7 | 28.4 | 21.2 | 6.3 | 65.7 | 5–7 | 271 | 2.84 | 17.74 | .864 | 28.3 | 26.5 | — |
| Lincoln, Neb. | 23.2 | 35.8 | 26.5 | 17.43 | 3.08 | 16.5 | 28 | 45.5 | 44.7 | 89.5 | 32.8 | 24.1 | 6.6 | 69.1 | 7–10 | 216 | 2.91 | 18.18 | .801 | 27.5 | 25.4 | — |
| Bozeman, Mont. | 91.4 | 46.3 | 44.4 | 14.55 | 2.73 | 10.0 | 51 | 45.8 | 44.3 | 90.3 | 39.7 | 41.1 | 6.2 | 75.3 | 7–10 | 160 | 2.35 | 14.67 | .588 | 25.0 | 23.5 | 3.74 |
| Fort Collins, Colo. | 53.1 | 40.3 | 39.5 | 13.99 | 2.66 | 11.8 | 44 | 46.6 | 44.9 | 90.1 | 35.0 | 31.0 | 6.0 | 73.8 | 7–10 | 160 | 2.31 | 14.43 | .610 | 26.4 | 25.5 | 4.20 |
| Fort Lewis, Colo. | 36.3 | 46.5 | 42.5 | 9.77 | 2.96 | 12.1 | 64 | 45.6 | 43.8 | 92.9 | 41.9 | 40.1 | 6.6 | 76.3 | 20 | 86 | 1.59 | 9.94 | .381 | 24.0 | 19.8 | 3.65 |
| Davis, Calif. | 69.9 | 44.2 | 39.2 | 10.64 | 2.87 | 13.8 | 73 | 45.8 | 42.9 | 92.2 | 38.5 | 36.2 | 5.6 | 76.7 | 15–20 | 126 | 1.69 | 10.59 | .510 | 30.2 | 28.5 | 4.91 |
| Average | 44.33 | 38.9 | 33.8 | 13.51 | 2.99 | 14.7 | 43 | 46.6 | 44.2 | 90.5 | 35.5 | 30.8 | 5.7 | 72.7 | 11.6 | 149.8 | 1.98 | 13.68 | .638 | 29.1 | 27.0 | 4.18 |

the grain. The barley yields at East Lansing, DeKalb, Kanawha, and Brookings were lower than in any of the previous years and the yields were slightly higher at Madison than in the two dry years, 1934 and 1936.

The general quality of the barleys showed a variation similar to that in yield at the different stations. The bushel weight and kernel weight of the barleys were usually low at the stations where stem rust was severe and about average at other stations. The barleys probably were more severely affected by rust at Madison, Wisconsin, than at any other station. The stem rust infection at Madison reduced bushel weight and kernel weight but did not reduce yield in bushels per acre below those of the unfavorable seasons of 1934 and 1936. In other words, the stem-rust epidemic seemed to affect bushel and kernel weight more than it did yield per acre.

The extract content of the malts showed the influence of the stem-rust epidemic in certain localities although the effect was not so clearly defined as in certain other quality factors. Extract content of the malts from all varieties was low at Madison, Wisconsin. The average extract for the five varieties at this station in 1937 was 68.1%, in contrast with 71.6% in the dry year 1936, 76.2% in 1935, and 70.2% in 1934. Extract content was low for the malts from Kanawha and Ames, Iowa, Brookings, South Dakota, Fargo, North Dakota, and Lincoln, Nebraska. The extract content of the malts from the other stations was about average except that those from Waseca, Minnesota, East Lansing, Michigan, and Bozeman, Montana, averaged higher than in the three previous years.

The nitrogen content of the barleys and malts was in general lower than in the previous year for most of the barleys grown in the main malting barley area and California. The two more southern stations, Urbana and DeKalb, Illinois, and the more western stations in the spring barley area (*i.e.*, Ames, Iowa, Brookings, South Dakota, Lincoln, Nebraska and Bozeman, Montana) produced barleys which were higher in nitrogen, in many instances, than in either 1935 or 1936.

Diastatic power of the malts showed a wide variation between stations and in general showed a distribution somewhat comparable to total nitrogen content of barleys and malts. This is shown also by the high correlation between nitrogen and diastatic power for the 1937 season, $r = +.8743$. The very high diastatic powers of the malts from Brookings, South Dakota (Table II), were rather unusual and worthy of special mention. The malt from the Manchuria had a diastatic power of 342, Oderbrucker 333, Velvet 224, Trebi 216, and Wisconsin Barbless 203° L. Diastatic values from Fargo, North Dakota, were also higher than usual. The malts from Madison,

Wisconsin, were low in diastatic power, averaging 112° L. for the five varieties in contrast with 130° L. in 1936 and 158° L. in 1935. The diastatic values on malts from East Lansing and Waseca were lower than usual.

The other factors determined on the barleys and malts showed a similar wide range between the different stations and years. For example the rate of water absorption was faster with the 1937 barleys, and hull content was much higher than in the previous years. Space will not permit a discussion of all of these in detail. The data are given in Table II and can be compared with the previous years by referring to the tables given in Barley and Malt Studies IV.[3]

### The Average for the Fourteen Stations Considered

The averages of the data from all fourteen stations show the relative quality of the barley varieties for the season of 1937, but these averages are not entirely comparable with those of previous years because the number of stations supplying samples varied from year to year (Table II). The averages for 1937 compared with those for all stations in previous years show that in 1937 the barleys were relatively low in bushel weight and had a slightly reduced kernel weight and a fairly mellow endosperm. The protein content was about the same as in 1935 and 1936, but not so high as in 1934. The extract content of the Velvet, Oderbrucker, and Manchuria malts was lower than in the two previous years, while that of Wisconsin Barbless and Trebi was slightly higher than in 1936 and appreciably higher than in 1934. The diastatic power of the malts was approximately the same as in 1936 except for the Wisconsin Barbless, which was significantly higher. In general, averages indicated enough stem-rust damage at several of the stations to decrease the kernel size and the extract without making a typically hard barley. This was also suggested in the reduced time required for water absorption.

### Six Stations Considered

The averages for six stations for each of the four years gives a direct comparison of the influence of seasonal conditions and the stem-rust epidemic upon the quality of the barleys and malts of the five standard varieties. The six stations included in the average are: East Lansing, Mich., Madison, Wis., Waseca, Minn., Kanawha, Ia., Brookings, S. D., and Bozeman, Mont. The varietal averages for four years (1934–1937) and the averages for the five varieties combined for each year are given in Table III. Yields in bushels per acre of

[3] See footnote 2.

TABLE III

AVERAGES FOR THE FIVE STANDARD VARIETIES FOR THE FOUR YEARS, 1934–1937, AND YEARLY AVERAGES FOR THE FIVE VARIETIES COMBINED FOR THE BARLEYS GROWN AT THE SIX STATIONS: EAST LANSING, MICH., MADISON, WIS., WASECA, MINN., KANAWHA, IA., BROOKINGS, S. D., AND BOZEMAN, MONT.

| Factors | Varietal average for 4 years (1934–1937) | | | | | Yearly average for 5 varieties | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Oderbrucker | Wisconsin Barbless | Velvet | Manchuria | Trebi | 1934 | 1935 | 1936 | 1937 |
| Acre yield barley (*bu.*) | 28.1 | 40.9 | 37.0 | 31.1 | 47.0 | 32.9 | 45.1 | 36.9 | 31.4 |
| Bushel weight barley, dry basis (*lbs.*) | 38.8 | 39.7 | 40.1 | 39.4 | 39.0 | 39.4 | 41.1 | 40.0 | 37.8 |
| Bushel weight malt, 4% basis (*lbs.*) | 35.9 | 36.5 | 36.1 | 35.2 | 35.6 | 36.1 | 37.9 | 35.3 | 34.2 |
| Kernel weight barley, dry basis (*mgs.*) | 25.7 | 27.3 | 25.3 | 24.6 | 33.7 | 29.8 | 27.0 | 26.3 | 26.1 |
| Kernel weight malt, dry basis (*mgs.*) | 22.8 | 24.5 | 22.4 | 21.7 | 30.5 | 27.1 | 23.5 | 23.5 | 23.5 |
| Hull content barley, dry basis (%) | 13.4 | 13.4 | 13.5 | 12.2 | 13.1 | 12.5 | 10.9 | 13.3 | 15.8 |
| Recovery malt from barley, dry basis (%) | 87.0 | 89.0 | 88.2 | 87.0 | 89.6 | 87.8 | 86.4 | 89.2 | 89.2 |
| Extract content, fine grind, dry basis (%) | 72.0 | 69.9 | 71.4 | 72.5 | 72.2 | 71.6 | 72.7 | 70.8 | 71.2 |
| Total protein in malt (%) | 15.6 | 14.6 | 14.8 | 15.2 | 14.0 | 16.5 | 14.3 | 14.3 | 14.2 |
| Soluble nitrogen in wort as protein (%) | 5.3 | 4.0 | 4.9 | 5.5 | 4.1 | 5.0 | 5.0 | 4.6 | 4.6 |
| Soluble nitrogen in relation to malt N (%) | 34.4 | 27.4 | 34.4 | 35.6 | 29.2 | 29.7 | 35.0 | 31.6 | 32.6 |
| Conversion time (min.) | 5.6 | 8.7 | 5.8 | 5.8 | 10.8 | 7.7 | 5.9 | 6.2 | 9.6 |
| Diastatic power (° L.) | 185 | 116 | 142 | 180 | 138 | 109 | 164 | 168 | 168 |

barley averaged low in 1937 and approximately the same as in 1934, which was a very dry year at five of the six stations. The varieties remained in the same order in yield during the four years with the exception that Wisconsin Barbless yielded higher than Trebi in 1935. The order of varieties from high yield to low was as follows: Trebi, Wisconsin Barbless, Velvet, Manchuria, and Oderbrucker. The average kernel weight of barley was lowest in 1937 for all varieties except Trebi. Average extract content was lowest in 1937 for the three varieties, Oderbrucker, Manchuria, and Velvet, and was higher for Wisconsin Barbless than in 1934 and 1936. Trebi was higher in average extract yield than in 1936. The average protein content of barleys and malts was relatively similar during the past three years. Likewise the average diastatic power for the malts of the five varieties was similar to the averages of previous years. The malts from the five varieties held the same relative order for diastatic power for the four years with the exception that Trebi malts were lower than the Velvet malts in 1934 and 1935. In general the malts from the six stations in 1937 were about the same quality as those of 1936 although seasonal conditions during the growing period were decidedly different in the two years. The stem-rust epidemic in 1937 seemed extensive and severe enough to reduce the average quality of the malts from the six stations as much as the continued hot, dry weather of 1936.

## Analysis of Variance

The data from the six stations where all five varieties were grown in four consecutive years were subjected to the analysis of variance. The results in terms of *F* values for some of the factors are presented in Table IV. In general the analysis shows the same type of reactions and interactions as reported on the three years data before this society a year ago. Briefly summarized, the varieties show significant differences for all factors except bushel weight of malt. The stations where the barleys were grown and years in which barleys were grown showed significant differences for all factors studied. The varieties held the same relative ranking at the six different stations for all of the factors except yield of grain and also held the same relative ranking for each of the four years for all factors except bushel weight of barley, protein content of malt, soluble nitrogen in wort, and diastatic power. And finally as might be expected, the stations interacted significantly with years, indicating that stations responded differently for all factors studied during the four seasons. The results suggest that factors making up quality are relatively stable within these five varieties and are not subject to differential responses caused by season or location, with the exceptions mentioned above.

TABLE IV

ANALYSIS OF VARIANCE OF YIELD, BUSHEL WEIGHT OF BARLEY AND MALT, KERNEL WEIGHT OF BARLEY AND MALT, RECOVERY OF MALT FROM BARLEY, EXTRACT IN MALT, PROTEIN IN MALT, SOLUBLE NITROGEN IN WORT, CONVERSION TIME IN MASHING, AND DIASTATIC POWER OF MALT

F values only are given for the factors and the 5% and 1% points.

| Variation due to | Degrees of freedom | F values | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yield of barley, bu. per A. | Bushel weight of barley | Bushel weight of malt | Kernel weight of barley | Kernel weight of malt | Recovery of malt from barley | Extract in malt, dry basis | Protein in malt | Soluble nitrogen in wort | Conversion time in mashing | Diastatic power of malt | 5% point | 1% point |
| Varieties | 4 | 38.0 | 3.1 | 2.2 | 185.5 | 85.6 | 10.3 | 10.6 | 14.4 | 181.2 | 16.8 | 55.5 | 2.52 | 3.65 |
| Stations | 5 | 158.1 | 223.8 | 75.2 | 197.7 | 89.3 | 3.7 | 32.8 | 43.5 | 49.5 | 3.3 | 25.0 | 2.37 | 3.34 |
| Years | 3 | 22.2 | 41.8 | 26.1 | 49.5 | 27.6 | 17.7 | 8.7 | 57.4 | 10.6 | 10.7 | 65.6 | 2.76 | 4.13 |
| Vars. × stas. | 20 | 2.6 | 1.1 | 0.7 | 0.9 | 1.2 | 0.7 | 0.6 | 1.3 | 1.6 | 1.1 | 1.5 | 1.77 | 2.24 |
| Vars. × yrs. | 12 | 0.7 | 2.8 | 0.9 | 1.0 | 1.1 | 1.0 | 0.8 | 2.7 | 1.9 | 1.2 | 2.8 | 1.92 | 2.50 |
| Stas. × yrs. | 15 | 9.4 | 31.3 | 5.9 | 32.0 | 11.6 | 7.0 | 10.9 | 25.2 | 13.3 | 4.4 | 11.5 | 1.86 | 2.40 |
| Vars. × stas. × yrs. | 60 | — | — | — | — | — | — | — | — | — | — | — | — | — |

## Correlations

Correlations between certain factors of barley and malt for the individual years and for the four years combined are given in Table V. The negative correlation between malt protein and extract is significant in 1934 and 1937 and in the combined data for the four years. There is a significant positive correlation of malt protein with diastatic power of malt and with soluble nitrogen in the worts for each individual year and for the combined four years. Low kernel weight of the barleys is correlated with high diastase and soluble nitrogen, and low extract.

TABLE V

CORRELATIONS BETWEEN CERTAIN FACTORS OF BARLEY AND MALT FROM THE STANDARD REGIONAL VARIETY SERIES FOR INDIVIDUAL YEARS AND FOR THE FOUR YEARS

| Factors correlated | Correlation values for years and four years | | | | |
|---|---|---|---|---|---|
| | 1934 | 1935 | 1936 | 1937 | Four |
| Protein, malt-extract, malt | −.6733 | −.2828 | −.1447 | −.4730 | −.3165 |
| Protein, malt-diastase, malt | +.6538 | +.4420 | +.6363 | +.8743 | +.3480 |
| Protein, malt-soluble N, wort | +.7950 | +.5167 | +.6382 | +.7209 | +.5476 |
| Kernel wt., barley-extract, malt | +.2514 | +.5955 | +.4835 | +.5172 | +.5796 |
| Kernel wt., barley-protein, barley | −.4842 | −.4092 | −.2346 | −.1900 | −.1296 |
| Kernel wt., barley-diastase, malt | −.4831 | −.6658 | −.0818 | −.2085 | −.3488 |
| Kernel wt., barley-soluble N, wort | −.6817 | −.7930 | −.6467 | −.5906 | −.6031 |
| Moisture content, malt-diastase malt | −.0702 | +.0664 | +.4000 | +.4656 | +.4150 |
| Moisture content, malt-soluble N, wort | −.0115 | −.0462 | −.2867 | −.1500 | −.0634 |
| Diastase, malt-conversion time in mashing | −.6200 | −.3810 | −.3870 | −.5546 | −.4265 |
| 5% point | .349 | .349 | .349 | .349 | .170 |
| 1% point | .449 | .449 | .449 | .449 | .230 |

The relation of kernel weight to barley protein is not so consistent. The barleys for the season of 1935, the year when all barleys apparently reached full development of the kernels, show significant correlations between kernel weight and a number of other factors. This suggests that kernel weight is of more importance in years when barley reaches full development, than in less favorable years. There is a significant negative correlation between diastatic power of the malts and conversion time in mashing.

The significant positive correlation between moisture content of the malt at the end of the drying period and diastatic power of the

malt is important, especially from the standpoint of methods of malting. The correlation values for the first two years are not significant, while those for the latter two years are significant. Sufficient data are not available to explain this difference in relationship between moisture and diastatic power. The relation between moisture content of the malt and diastatic power is known to maltsters and malting chemists as is shown by the differences in moisture content of brewers' and distillers' malts. Numerous other correlations concerning barley and malt characteristics have been calculated but will be reserved for later papers.

In summation, the malts from the barleys produced in 1937 at approximately one-half of the stations approached the quality of the malts from barleys grown in the two other unfavorable years of 1934 and 1936. In certain quality characteristics the barleys and malts differed from those of the two unfavorable years.

## Summary

Two control barleys were used with those malted and analyzed in the study of the 1937 samples. Variability in certain factors in the controls was reduced somewhat below that of the previous years, in certain other factors it remained about the same, while in still others it increased.

The barleys grown in 1937 at most of the stations in the north-central area were reduced in quality somewhat by the epidemic of stem rust. These barleys were low in yield and bushel and kernel weight and high in hull content. The barleys had about average protein and relatively high ash, approaching that of 1935. The endosperm however was mellow and rate of water absorption rather rapid.

The malts produced from the five standard varieties were somewhat low in extract, slightly low in soluble nitrogen, and about average in protein and diastatic power.

The statistical study of the four years' data for the five standard varieties grown at six stations shows that the varieties, stations where grown, and seasons in which they were grown all had a significant influence on most of the factors studied. The analysis indicates that the five varieties used in the investigations remained in essentially the same ranking at each of the stations where they were grown and in each year grown. However, stations responded differentially in certain years.

Correlations are given for a few of the factors determined on the barleys and malts for the individual years and for the total of the four years. The correlations suggest a different relationship between certain factors in the several years.

# APPLICATION OF THE ALUMINUM-PLATE MOISTURE METHOD IN THE MALTING LABORATORY

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Much work has already been done on methods for the determination of moisture in cereals and cereal products with an ever increasing trend toward methods which are accurate, convenient, and at the same time more rapid than the official methods recognized. Out of these researches have come the facts which are the basis for the more rapid air-oven moisture tests. Davis (1935) showed that by feeding the drying oven with forced draft by means of a vacuum pump attached to the top of the drying-chamber outlet, and raising his temperature to 140°C. for 20 minutes, results could be obtained with wheat flour which were comparable to those by the one-hour method at 130°C. Sandstedt (1938) obtained particularly pleasing results by drying his flour samples on an half-inch aluminum plate for 20 minutes at 140°C. From this work, as also from Anderson (1936), who reduced the time necessary for his samples to come to the temperature of the vacuum oven (100°) from 1½ hours to 10 minutes, by circulating steam through the hollow brass plate on which the samples rested, comes the indication that the problem in rapid drying lies not so much in the removal of vapor accumulating over the drying samples as in the transfer of the required heat to the said samples.

Raising the heating temperature, with corresponding decrease of time in drying, might be another means to the required end, but Davis (1935) and also Treloar and Sullivan (1935) have shown that drying materials such as flour or feed at excessively high temperatures will yield high results because of the decomposition and destructive changes of organic materials present. This latter point is of particularly greater importance in the testing of malt because of the presence of the simpler forms of carbohydrates and proteins and interaction products of these, made available during the process of malting.

With all these facts in view and at the same time considering the fact that work has chiefly been confined to the cereals concerned in the foods and milling industries, it appeared very desirable to apply this line of research to the determination of moisture in the malting control laboratory. It was decided to determine whether or not the aluminum-plate method as recommended by Sandstedt (1938) with certain necessary modifications of time and temperature could be used.

## Experimental

Since the malting laboratory is concerned not only with determinations of the raw grain samples, but also with two types of malt, the tests were run as two independent series, one with the grain and one with the malt, to arrive at optimum conditions. These conditions would necessarily have to yield results comparable to those derived from the methods accepted as standard or official.

One series of tests entailed raw barley samples ground to a floury consistency, and the method of comparison for moisture taken was one recommended by the A. A. C. C. (1935)—namely the air-oven method, 130° for one hour. The other series concerned the processed malt, ground in a Miag-Seck mill, to specifications of the A. S. B. C. (1935) *i.e.*, to yield an approximately 90% grind through a No. 30 U. S. standard sieve. The method of comparison was the official moisture method of the A. S. B. C.—drying approximately 5 grams at 103–5° for three hours.

In this latter series we have brewer's malt, manufactured with a moisture content of approximately 4%, and distiller's malt, which contains about 6% moisture. Because of the comparatively wide range in moisture content between these two types it was decided to run samples in triplicate of each, in separate groups, by both standard and experimental methods. The comparative averages for each sample are given in Table II.

While all the tests were run in the regular Cenco De Khotinsky (new model), the experimental methods were conducted with a solid half-inch aluminum plate used as a tray in the oven for the moisture dishes to sit on, in place of the regular grid shelf. The oven temperatures (read with the bulb buried in a tin of sand, on the aluminum plate) were adjusted to 125°C. for malt and 140°C. for the barley tests.

An half-inch aluminum plate held at room temperature was used to cool the samples dried on the plates in the oven as recommended by Sandstedt (1938). Desiccators were used, however, for all samples heated according to the standard methods. The moisture tins cooled to room temperatures quite comfortably within five minutes. Should longer time be necessary Sandstedt (1938) advises completion of cooling in the desiccator.

The moisture dishes used in both the standard methods for malt and barley and in the corresponding short aluminum-plate method were 55 mm. in diameter and 15 mm. deep. Since approximately five-gram samples are recommended in the standard malt analysis, the same amount was used in the experimental method, while two-gram samples sufficed in all the barley tests to conform with the quantity specified by the A. A. C. C. (1935).

## Results

In Table I are shown the results of a test with malt which confirm data shown by Sandstedt (1938), in the elimination of variations in results due to position in the regular air-oven method on the grid shelf, by using the aluminum-plate method. These results are similar to those of several tests run.

While the variations in the regular air-oven method were rather small, there does appear a tendency toward a slightly higher reading at the back of the oven, except for the left rear corner, with lower readings at the front. This tendency, though small, was noted in all such tests run. On the aluminum plate, however, in the experimental method, it apparently is overcome and results appear uniform, irrespective of position in the oven.

TABLE I

EFFECT OF POSITION IN OVEN USING STANDARD METHOD AND THE ALUMINUM-PLATE METHOD

| Position in oven | Moisture by standard method | Moisture—125° for 15 min. |
|---|---|---|
| | % | % |
| Left rear corner | 4.04 | 4.10 |
| Center rear side | 4.07 | 4.12 |
| Right rear corner | 4.13 | 4.09 |
| Left center side | 4.06 | 4.16 |
| Center | 3.98 | 4.03 |
| Right center side | 4.04 | 4.04 |
| Left front corner | 4.02 | 4.03 |
| Center front side | 4.00 | 4.13 |
| Right front corner | 3.97 | 4.10 |

Having confirmed the unimportance of position on the aluminum plate, we placed all replicate samples in subsequent tests on the shelf at random.

Table II shows that while heating for 15 minutes at 125°C. appears to give slightly higher results than the standard method in the majority of cases, decreasing the time to 10 minutes made the drying period too short, particularly for samples with higher moisture, such as distiller's malt.

It is well to note here that the time periods indicated in the experimental methods were considered from the time the oven temperature had risen back to that set, after the oven had been loaded. This was found to yield more uniform and consistent results and overcame the varying lengths of time taken by the oven in returning to required

TABLE II

AVERAGE MOISTURE DETERMINATIONS ON MALT BY STANDARD METHODS AND BY ALUMINUM-PLATE METHOD AT 125°

| Sample No. | Standard method | Aluminum-plate method 125°, 15 min. | Aluminum-plate method 125°, 10 min. |
|---|---|---|---|
| Brewer's Malt 1 | 4.29 | 4.29 | — |
| 2 | 3.71 | 3.79 | 3.66 |
| 3 | 4.16 | 4.11 | 4.04 |
| 4 | 3.77 | 3.79 | 3.66 |
| 5 | 3.99 | 4.06 | 3.91 |
| 6 | 3.79 | 3.84 | — |
| Distiller's Malt 1 | 5.91 | 5.93 | 5.75 |
| 2 | 5.96 | 6.08 | — |
| 3 | 6.03 | 6.11 | 5.90 |
| 4 | 5.90 | 5.96 | — |
| 5 | 6.18 | 6.22 | 6.01 |
| 6 | 6.21 | 6.10 | 6.03 |

temperature, depending on the time its door was open while the samples were put in.

Tests made with the raw grain (only barley was here considered) compare very favorably with results shown by Sandstedt (1938) for ground wheat. In Table III are shown the comparative averages of three replicates for each of six different barley samples by the standard method for cereals (A. A. C. C. 1935) (drying for one hour at 130°C.) and by the short method, at 140°C. for 20 minutes.

TABLE III

COMPARATIVE RESULTS OF AVERAGES OF BARLEY SAMPLES, RUN BY STANDARD METHOD AND BY ALUMINUM-PLATE METHOD—140° FOR 20 MINUTES

| Sample No. | Moisture, 130° for 1 hour | Moisture, 140° for 20 min. |
|---|---|---|
| | % | % |
| 1 | 11.18 | 11.28 |
| 2 | 13.58 | 13.57 |
| 3 | 14.13 | 14.12 |
| 4 | 12.67 | 12.60 |
| 5 | 11.62 | 12.60 |
| 6 | 11.20 | 11.20 |

## Summary and Conclusions

The short aluminum-plate method promises to be of some use in the malting control laboratory. While it requires a little care and caution in the adjustment of time and temperature, and may lack some of the efficiency of the longer standard method, its time-saving character makes it worthy of consideration.

This plate method, as used with the raw cereal, can apparently be used satisfactorily, with considerable degree of accuracy.

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## DOUGH OXIDATION AND MIXING STUDIES
## I. THE ACTION OF POTASSIUM BROMATE IN DOUGH

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(Read at the Annual Meeting, May 1938)

Bread improvers are used to produce desirable improvements in dough. However, good results are not always obtained; under certain conditions the effects of improvers may actually be detrimental. While studying the effects of various bread improvers, we have found that undesirable results in straight doughs might be overcome by remixing them after fermentation.

In a study of the factors concerned in producing these results it was found that the oxidizing agent in the bread improver was responsible for the undesirable results obtained in straight doughs as well as for the great improvement produced by remixing such doughs after fermentation. In the data given below, we shall present a study of the factors involved in the action of potassium bromate in doughs. The factors concerned in the effects of remixing after fermentation will be considered in Section II of this series.

### The " Excess Bromate " Effect

Jørgensen has studied the effect of oxidizing agents, such as potassium bromate, on doughs. Similar studies, covering a period of years, have been conducted at the Fleischmann Laboratories.

The action of potassium bromate in dough may be illustrated by its effects in the presence of added papain, a powerful proteolytic enzyme. The volume figures in Table I and Figure 1 show that the

TABLE I

EFFECT OF $KBrO_3$ ON THE ACTIVITY OF ADDED PAPAIN IN DOUGH

| | Loaf volume |
|---|---|
| | *cc.* |
| Control (no papain, no bromate) | 2050 |
| Papain 75 mg., bromate none | 1370 |
| Papain 75 mg., bromate 5 mg. | 1380 |
| Papain 75 mg., bromate 10 mg. | 1380 |
| Papain 75 mg., bromate 15 mg. | 1450 |
| Papain 75 mg., bromate 20 mg. | 1520 |
| Papain 75 mg., bromate 25 mg. | 1630 |
| Papain 75 mg., bromate 30 mg. | 1840 |
| Papain 75 mg., bromate 40 mg. | 1920 |
| Papain 75 mg., bromate 50 mg. | 2020 |
| Papain 75 mg., bromate 60 mg. | 2000 |
| Papain 75 mg., bromate 70 mg. | 1990 |
| Papain 75 mg., bromate 80 mg. | 1990 |
| Papain 75 mg., bromate 100 mg. | 1920 |

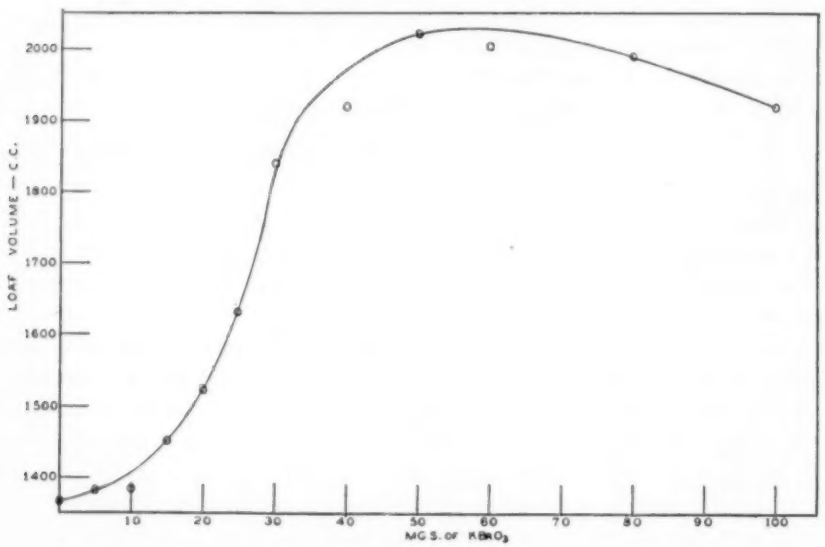


Fig. 1. Effects of increasing amounts of bromate in doughs containing 75 mg. of papain.

proteolytic effects of papain were largely overcome by additions of bromate to the dough; this was also apparent from the condition of the doughs and the appearance of the baked bread.

It will be observed that the volume produced by 100 mg. of bromate is distinctly lower than the optimum; the loaf showed evidence of

what we have designated as the "excess bromate" effect. We have been familiar with this reaction for a number of years, but it has been difficult to develop a satisfactory explanation. Figure 2 shows photo-

Fig. 2. The "excess bromate" effect, and its elimination by remixing after fermentation.

graphs of a no-bromate control, a loaf with 100 mg. of bromate showing a very strong "excess bromate" effect, and a loaf with 100 mg. of bromate made from a dough which was remixed after fermentation. The "excess bromate" effect is characterized by what bakers sometimes refer to as a "bucky" dough, and a loaf of poor volume, rounded corners, rough exterior, a tendency to form a peak on the upper part of the loaf, and poor, heavy, lumpy, coarse texture. We have been particularly interested in this effect, because it is quite common in lean, straight-dough formulas, and goes beyond any point at which it might be explained as due to retardation of proteolytic activity.

Table II and Figure 3 show the effects of excessive amounts of bromate on loaf volume.

TABLE II

EFFECTS OF INCREASING AMOUNTS OF $KBrO_3$ ON LOAF VOLUME

Dough time, 2 hours; pan proof time, 50 min.; pH of bread, 5.48

| | Loaf volume |
|---|---|
| | *cc.* |
| Control (no bromate) | 2140 |
| Bromate 4 mg. | 2130 |
| Bromate 10 mg. | 2020 |
| Bromate 20 mg. | 1900 |
| Bromate 50 mg. | 1790 |
| Bromate 100 mg. | 1710 |
| Bromate 500 mg. | 1610 |
| Bromate 1000 mg. | 1570 |

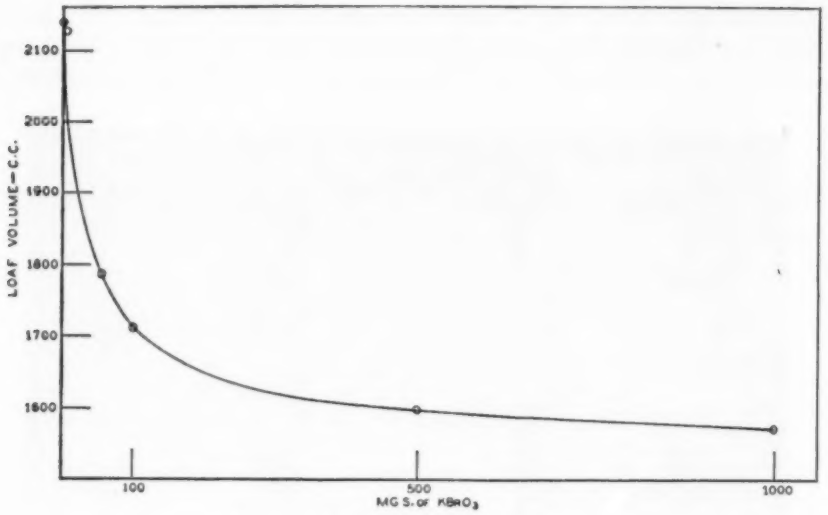


Fig. 3. Effect of bromate on loaf volume.

There is a very sharp decrease in loaf volume, accompanied by increasingly marked "excess bromate" effects, up to about 100 mg., beyond which further increases in the amount of bromate in the dough produce comparatively slight changes in the volume and character of the resulting bread. Qualitative tests indicated a slight amount of undecomposed bromate in the 100-mg. loaf and large amounts in the 500- and 1000-mg. loaves.

The amount of acid developed in the dough as a result of fermentation was possibly a factor limiting the amount of bromate decomposed. This conclusion may be drawn from the results shown in Table III and Figure 4, where the fermentation was prolonged to produce greater acidity in the dough.

Figure 4 shows that 20 mg. of bromate, which is usually considered a large excess, actually produced an increase in volume in the very early stages of fermentation. With increasing fermentation time and the resulting increase in acidity as shown by the pH changes in Table III, th e is a progressive decrease in loaf volume to a value much lower than that shown for 20 mg. of bromate in Table II. After three hours of fermentation the change in volume is slight in comparison to the change in pH.

Similar tests with 20, 50, 75, 100, and 200 mg. of bromate were made with another lot of the same kind of flour at a later date. The loaf volume figures are given in Table IV and plotted in Figure 5.

TABLE III

EFFECTS OF INCREASING FERMENTATION TIME ON LOAF VOLUME AND pH, FOR DOUGHS WITH 20 MG. OF $KBrO_3$

| Dough time | Sugar | Pan proof | Loaf volume | pH of bread |
|---|---|---|---|---|
| *Hrs.* | *%* | *min.* | *cc.* | |
| None | 5 | 87 | 2060 | 5.70 |
| ¼ | 5 | 76 | 2110 | 5.70 |
| ½ | 5 | 73 | 2190 | 5.70 |
| 1 | 5 | 61 | 2110 | 5.70 |
| 1½ | 5 | 55 | 2010 | 5.67 |
| 2 | 5 | 59 | 1880 | 5.62 |
| 3 | 5 | 50 | 1770 | 5.49 |
| 4 | 6 | 50 | 1740 | 5.41 |
| 5 | 7 | 59 | 1730 | 5.29 |
| 6 | 8 | 65 | 1680 | 5.26 |

In texture, the 0, ¼, and ½-hour loaves were immature; the 1-hour loaf was nearly normal; the 1½-hour loaf showed a distinct "excess bromate" effect; and the 2, 3, 4, 5, and 6-hour loaves showed progressively greater "excess bromate" effects, with the 4, 5, and 6-hour loaves quite similar to each other in that respect.

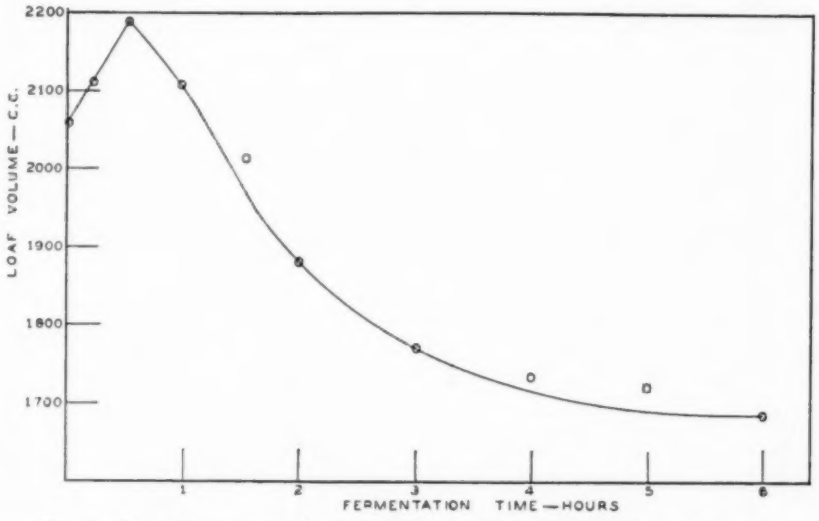


Fig. 4. Effect of fermentation time on loaf volume in doughs containing 20 mg. of bromate.

From a study of the curves shown in Figure 5 the following conclusions seem justified:

1. Excessive amounts of bromate produce great decreases in loaf volume with increasing fermentation time.

2. Loaf volume also decreases as the amount of bromate is increased; this effect seems to be independent of the amount of fermentation and indicates that bromate may produce changes in dough even in the absence of fermentation.

TABLE IV

EFFECTS OF INCREASING FERMENTATION TIME ON LOAF VOLUME WITH VARYING AMOUNTS OF $KBrO_3$ [1]

| Dough time | Loaf volumes with specified mg. of $KBrO_3$ | | | | |
|---|---|---|---|---|---|
| | 20 | 50 | 75 | 100 | 200 |
| *Hrs.* | *cc.* | *cc.* | *cc.* | *cc.* | *cc.* |
| 0 | 1930 | 1990 | 1930 | 1870 | 1720 |
| ¼ | — | 2020 | — | 1900 | 1670 |
| ½ | 2070 | 2020 | 1930 | 1680 | 1620 |
| 1 | 2050 | 1760 | 1710 | 1640 | 1570 |
| 1½ | — | 1720 | — | — | 1540 |
| 2 | 1770 | 1650 | 1630 | 1570 | 1510 |
| 3 | 1640 | — | 1550 | 1500 | — |
| 4 | — | 1550 | — | — | 1490 |
| 5 | — | — | — | — | 1470 |
| 6 | 1530 | 1520 | — | — | 1470 |

[1] Differences in percentage of sugar, pan proof time, and pH were similar to those shown in Table III.

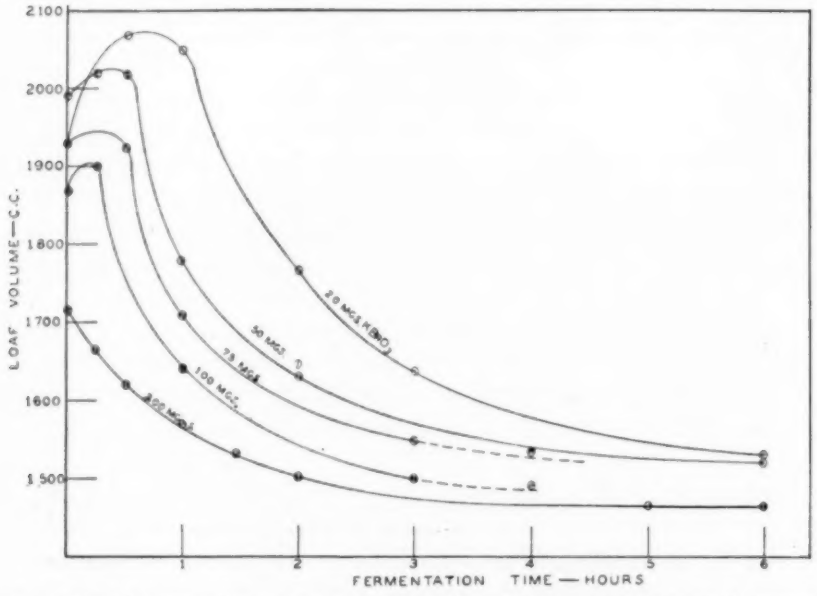


Fig. 5. Effect of fermentation time on loaf volume in doughs with increasing amounts of bromate.

3. There is a tendency for bromate to improve loaf volume; this effect decreases with increasing amounts of bromate and is also affected by the amount of fermentation.

4. The decreases in volume approach a limiting value which seems to be partly dependent on the volume of the dough at the end of the pan proof period, when the dough is placed in the oven; this value is about 1400 cc. in doughs showing the "excess bromate" effect.

5. The figures for the 20-mg. loaves were different for different lots of flour (Tables III and IV), but the curves were parallel, showing that the reaction was of the same type.

It is believed that the "excess bromate" effect is a result of the combined effects of bromate and fermentation.

**Influence of Fermentation Products in the " Excess Bromate " Effect**

To determine whether the "excess bromate" effect was partly due to specific effects of the products of yeast fermentation, pyruvic acid and acetaldehyde, which are considered as intermediate products of alcoholic fermentation,[1] were compared to hydrochloric acid in doughs with and without bromate. The results are given in Table V.

TABLE V

EFFECTS OF PYRUVIC ACID, ACETALDEHYDE, AND HYDROCHLORIC ACID ON LOAF VOLUME AND pH IN DOUGHS WITH AND WITHOUT $KBrO_3$

| | Loaf volume | pH of bread |
|---|---|---|
| | *cc.* | |
| Control | 2120 | 5.63 |
| Bromate—20 mg. | 1900 | 5.61 |
| HCl, N/1—5 cc. | 1830 | 5.11 |
| Pyruvic acid—0.45 g. | 1860 | 5.19 |
| Acetaldehyde—0.65 g. | 1920 | 5.23 |
| Bromate—20 mg. plus HCl, N/1—5 cc. | 1510 | 5.07 |
| Bromate—20 mg. plus pyruvic acid—0.45 g. | 1560 | 5.20 |
| Bromate—20 mg. plus acetaldehyde—0.65 g. | 1650 | 5.21 |

From these limited results it does not appear that pyruvic acid and acetaldehyde would be any more effective than HCl at about the same pH.

Having observed that 20 mg. of bromate produced good loaf volume after a very short fermentation period, experiments were conducted to determine whether the addition of acid to very young doughs would produce the "excess bromate" effects resulting from prolonged fermentation. The results of these tests are given in Table VI.

There is a definite decrease in volume with increasing amounts of added acid in these young doughs, but the volumes are much greater than those of the bread at about the same pH shown in Table III, where the dough acidity was produced by fermentation.

Since $CO_2$ is one of the products of fermentation, it appeared desirable to note whether it was a contributing factor in the "excess bromate" effect. Experiments with bromate in young doughs with

[1] A. Harden: New light on the chemistry of alcoholic fermentation, J. Inst. Brewing **39**: 644–646 (1933).

TABLE VI

EFFECTS OF ADDED ACID ON LOAF VOLUME AND pH IN DOUGHS WITH 20 MG. $KBrO_3$
Dough time, 30 min.; pan proof time, 70 min.

| *n*/10 HCl | Loaf volume | pH of bread |
|---|---|---|
| *cc.* | *cc.* | |
| 0 | 2160 | 5.69 |
| 5 | 2180 | 5.60 |
| 10 | 2140 | 5.54 |
| 20 | 2070 | 5.41 |
| 30 | 2020 | 5.24 |
| 40 | 1900 | 5.11 |
| 50 | 1850 | 5.00 |

With the exception of the last three loaves, textures were all satisfactory, and the loaf having a pH of 5.11 was the first to show a distinct "excess bromate" effect. In contrast to this, the loaf having a pH of 5.62 showed a strong "excess bromate" effect, in the tests in which dough acidity was produced by fermentation (Table III).

added acid were therefore made in which the doughs were mixed in an atmosphere of $CO_2$ under slight pressure. Table VII shows the results of these tests. (Figure 6 is a photograph of the Hobart-Swanson mixer, as used for mixing doughs in $CO_2$ and other gases.)

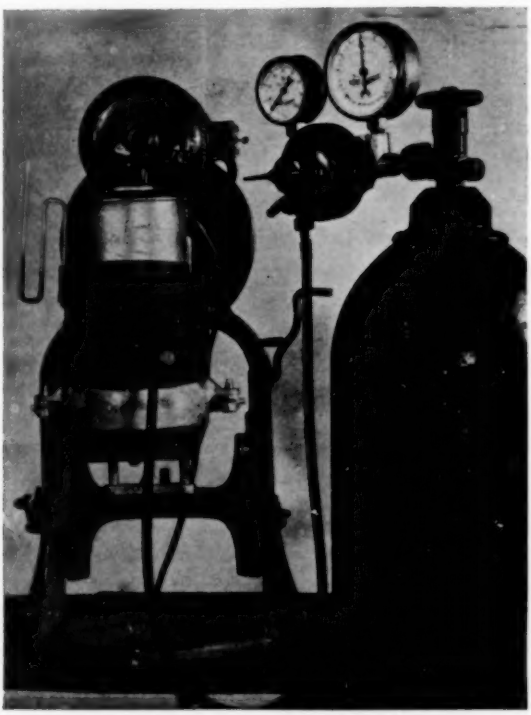

Fig. 6. Hobart-Swanson mixer, as used for mixing doughs in different gases; mixing bowl and mixer head are enclosed in rubber and manometer indicates pressure within mixing chamber.

TABLE VII

EFFECTS OF ADDED ACID AND MIXING IN $CO_2$ ON LOAF VOLUME AND pH IN DOUGHS WITH 20 MG. OF $KBrO_3$

Dough time, 30 min.; pan proof time, 70 to 75 min.

| *n*/10 HCl | Loaf volume | pH of bread |
|---|---|---|
| *cc.* | *cc.* | |
| 0 | 2070 | 5.66 |
| 5 | 2040 | 5.61 |
| 10 | 1960 | 5.54 |
| 20 | 1840 | 5.41 |
| 30 | 1790 | 5.28 |
| 40 | 1790 | 5.13 |
| 50 | 1740 | 5.01 |

The texture of the first two loaves was satisfactory; the loaf of pH 5.41 was the first to show a distinct "excess bromate" effect.

It is evident that the changes in volume and bread characteristics were very marked, indicating that $CO_2$ was definitely a factor in the "excess bromate" effect.

Figure 7 shows the changes in volume with decreasing pH resulting

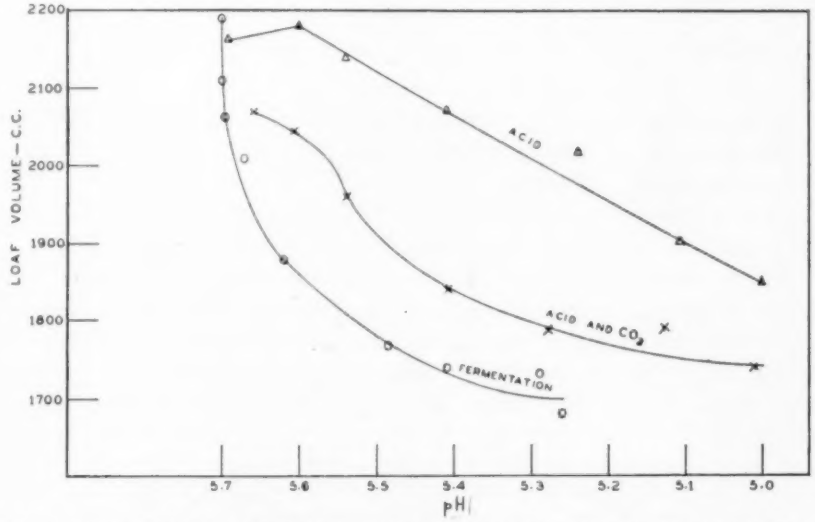


Fig. 7. Comparison between effects of fermentation, added acid, and added acid with mixing in $CO_2$ on changes in loaf volume due to decreasing pH, in doughs containing 20 mg. of bromate.

from (*a*) fermentation, (*b*) added acid, and (*c*) added acid and mixing in $CO_2$ (data from Tables III, VI, and VII). It is evident that the curve for acid plus $CO_2$ is parallel to, but does not coincide with, the fermentation curve, indicating that there may be one or more additional factors involved.

It should be noted that the $CO_2$-plus-acid loaves had about the same pH as those with acid alone; $CO_2$ does, however, produce a difference in pH right after mixing, as shown in Table VIII.

TABLE VIII

CHANGES IN pH OF FERMENTING DOUGHS MIXED IN AIR AND IN $CO_2$

| | Dough mixed in air | Dough mixed in $CO_2$ |
|---|---|---|
| pH after mixing | 5.98 | 5.72 |
| pH after 1 hour | 5.60 | 5.65 |
| pH after 2 hours | 5.49 | 5.48 |
| pH after pan proof (3¼ hrs.) | 5.29 | 5.33 |
| pH of baked bread | 5.48 | 5.48 |

It is apparent that the pH of the dough mixed in $CO_2$ was much lower than that of the dough mixed in air right after mixing, but this difference disappeared within the first hour, evidently as a result of the production of $CO_2$ by fermentation in the dough mixed in air.

## Summary

Bromate was found to produce effects in addition to and apparently different from direct inhibition of proteolytic activity.

The acid produced by fermentation in dough was found to be one of the important factors involved in the effects of bromate on the quality of the bread produced.

The carbon dioxide produced by fermentation in dough was found to be another important factor involved in the effects of bromate.

With fermentation time a constant, the effects of bromate were found to vary with the amount of bromate used; this was true even in doughs with very short fermentation periods, indicating that oxidizing agents such as bromate may produce specific effects. To obtain certain reactions of bromate in doughs, fermentation may not be necessary.

# DOUGH OXIDATION AND MIXING STUDIES
## II. EFFECTS OF REMIXING AFTER FERMENTATION

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(Read at the Annual Meeting, May 1938)

It has been stated in Section I of this series that remixing after fermentation produced very marked improvements in doughs which would otherwise produce "excess bromate" effects. Table I shows the changes in volume produced by remixing after fermentation in doughs with (*a*) different amounts of bromate, (*b*) different fermentation periods, and (*c*) very young doughs made with added acid and bromate, which were mixed in $CO_2$.

TABLE I

CHANGES IN LOAF VOLUME PRODUCED BY REMIXING DOUGHS AFTER FERMENTATION

| Bromate | Loaf volume | Remixed after fermentation—loaf volume |
|---|---|---|
| DOUGHS WITH VARYING AMOUNTS OF $KBrO_3$; DOUGH TIME 2 to 2½ HRS. | | |
| *mg.* | *cc.* | *cc.* |
| 0 | 1990 | 1980 |
| 5 | 1900 | 2160 |
| 10 | 1860 | 2160 |
| 20 | 1680 | 2250 |
| 40 | 1640 | 2210 |
| 60 | 1550 | 2120 |
| 100 | 1500 | 2150 |
| 250 | 1480 | 2170 |
| 500 | 1420 | 2150 |
| 1000 | 1420 | 2140 |
| DOUGHS WITH 20 MG. OF $KBrO_3$ FERMENTED 2 AND 6 HOURS | | |
| | *cc.* | *cc.* |
| Dough time 2 hrs. | 1880 | 2190 |
| Dough time 6 hrs. | 1680 | 2160 |
| DOUGHS WITH 20 MG. BROMATE, 20 CC. *n*/10 ACID, MIXED IN $CO_2$, DOUGH TIME ½ HR. | | |
| | *cc.* | |
| Not remixed | 1930 | |
| Remixed after fermentation | 2150 | |

It is evident from these results that remixing after fermentation completely neutralized these "excess bromate" effects, whether produced by large amounts of bromate, prolonged fermentation, or by the addition of acid and $CO_2$ to a very young dough.

It had been observed that during remixing of doughs with large amounts of bromate, the doughs became very sticky and stringy if

overmixed. Experiments were therefore conducted to determine the effects of variations in remixing time with doughs containing different amounts of bromate. Table II and Figure 1 show the results of experi-

TABLE II

LOAF VOLUME AND pH FOR DOUGHS WITH 0, 20, AND 100 MG. OF $KBrO_3$, REMIXED AFTER FERMENTATION FOR VARYING TIME INTERVALS

Doughs mixed 2 min. and remixed as indicated in Hobart-Swanson mixer—Dough time, 2 hours; pan proof time, 50 to 55 minutes

| Remixing time *Min.* | Loaf volume *cc.* | pH of bread |
|---|---|---|
| | DOUGHS WITH NO BROMATE | |
| ½ | 1960 | 5.43 |
| 1 | 2030 | — |
| 1½ | 2150 | 5.40 |
| 2 | 2130 | — |
| 4 | 2160 | 5.38 |
| | DOUGHS WITH 20 MG. OF BROMATE | |
| ½ | 1720 | 5.43 |
| 1 | 2050 | — |
| 1½ | 2190 | 5.41 |
| 2 | 2230 | — |
| 4 | 2070 | 5.37 |
| | DOUGHS WITH 100 MG. OF BROMATE | |
| ½ | 1710 | 5.43 |
| 1 | 2140 | — |
| 1½ | 2190 | 5.41 |
| 2 | 2100 | — |
| 4 | 1770 | 5.37 |

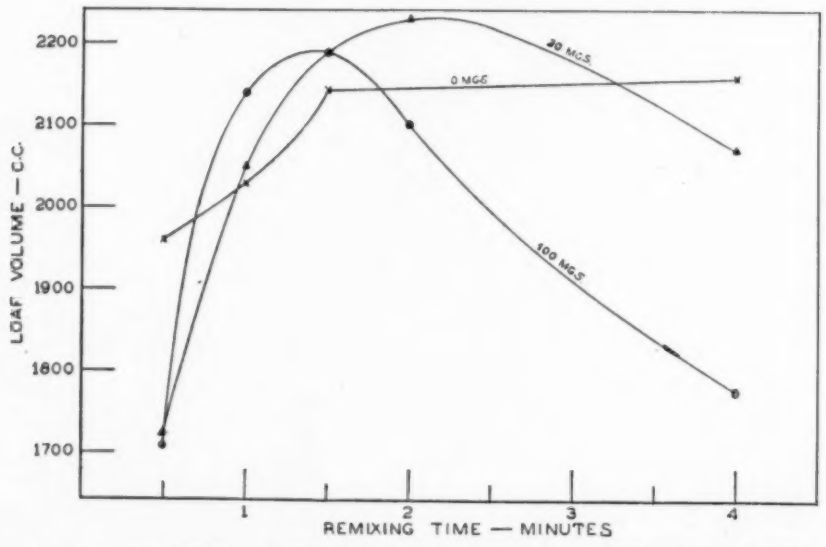


Fig. 1. Effects of variations in remixing time on doughs containing different amounts of $KBrO_3$.

ments with doughs containing 0, 20, and 100 mg. of bromate, and remixed after fermentation for ½, 1, 1½, 2 and 4 minutes. The doughs were all mixed and remixed in the Hobart-Swanson mixer.

The changes in volume produced by remixing were accompanied by changes in texture and exterior appearance. In the 20-mg. series, the differences were much greater than in the no-bromate series; the ½-minute loaf showed a strong "excess bromate" effect; the 1, 1½, and 2-minute loaves were about normal in texture though the grain was somewhat open; the 4-minute loaf showed an apparent "proteolytic" effect; that is, the bread was similar in appearance to that made from dough with added papain. We have designated this condition as the "excess-remixing" effect. The loaves in the 100-mg. series were similar to the 20-mg. loaves, but 4 minutes of remixing produced a much stronger excess-remixing effect than in the 20-mg. series.

The differences produced were very striking. A study of the curves led us to the following conclusions:

1. Each curve shows an optimum volume after 1½ to 2 minutes of remixing time.
2. The optimum for the bromate doughs is greater than for the no-bromate doughs.
3. The initial volume of the bromate doughs is much lower than that of the no-bromate doughs.
4. The change in volume per unit of mixing time increases with the bromate content of the doughs; the 100-mg. curve shows an increase in volume of over 400 cc. due to a change in remixing time of 30 seconds.
5. There was no change in volume after the optimum was reached with the no-bromate doughs, but there was a considerable decrease in volume with the 20-mg. doughs and a very sharp decrease with the 100-mg. doughs.
6. There was a slight but measurable decrease in pH, which varied as the remixing time.
7. The dough with 20 mg. of bromate was sticky and stringy after 4 minutes of remixing, and the 100-mg. dough was very much more so and could not be handled.
8. The loaf made from the 100-mg. dough with 4 minutes of remixing showed a very strong excess-remixing effect.

To determine whether mixing in oxygen initially would produce remixing curves similar to those obtained with bromate, doughs without bromate were mixed in nitrogen, in oxygen, and then remixed in air after fermentation for ½, 1, 1½, 2, and 4 minutes. The results of these experiments are shown in Table III, with figures for comparable

doughs mixed in air from Table II; in Figure 2 these results are shown graphically.

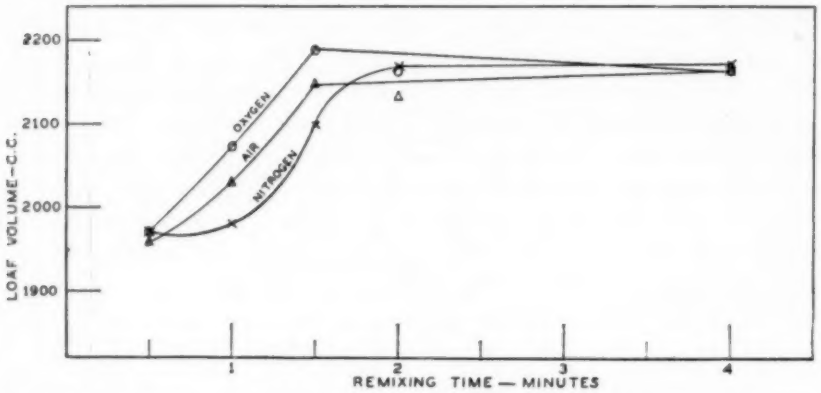


Fig. 2 Effects of variations in remixing time on doughs without bromate, which were originally mixed in nitrogen, air and oxygen.

## TABLE III

LOAF VOLUME AND pH FOR DOUGHS WITHOUT BROMATE, MIXED 2 MINUTES IN NITROGEN, AIR AND OXYGEN, AND REMIXED IN AIR AFTER FERMENTATION FOR VARYING TIME INTERVALS

Dough time 2 to 2½ hours; pan proof time, 50 to 55 min.; doughs mixed and remixed in Hobart-Swanson [1]

| Remixing time [2] | Loaf volume | pH of bread |
|---|---|---|
| *Min.* | *cc.* | |
| DOUGHS WITH NO BROMATE—MIXED IN NITROGEN | | |
| ½ | 1970 | 5.46 |
| 1 | 1980 | — |
| 1½ | 2100 | 5.41 |
| 2 | 2170 | — |
| 4 | 2170 | 5.39 |
| DOUGHS WITH NO BROMATE—MIXED IN AIR | | |
| ½ | 1960 | 5.43 |
| 1 | 2030 | — |
| 1½ | 2150 | 5.40 |
| 2 | 2130 | — |
| 4 | 2160 | 5.38 |
| DOUGHS WITH NO BROMATE—MIXED IN OXYGEN | | |
| ½ | 1970 | 5.43 |
| 1 | 2070 | — |
| 1½ | 2190 | 5.42 |
| 2 | 2160 | — |
| 4 | 2160 | 5.39 |

[1] Figure 6, Dough Oxidation and Mixing Studies I (page 492), shows the Hobart-Swanson as used for mixing dough in oxygen and nitrogen.

[2] The ½- and 1-minute loaves in the nitrogen series, and ½-minute loaves in the air and oxygen series were not as good as those mixed for longer periods. The latter were about normal in texture, though more open than usual.

The curves in Figure 2 are qualitatively similar to those of Figure 1 only on the side approaching the optimum.

1. Oxygen and air show an optimum at 1½ minutes of remixing time, but for nitrogen the approach is more gradual, so that the optimum is reached at 2 minutes.

2. The change in volume per unit of mixing time increases with the oxygen content, but is very much less than for the bromate doughs (Fig. 1).

3. There is no decrease in volume after the optimum is reached, in contrast to the bromate doughs, which showed sharp decreases beyond the optimum (Fig. 1).

It is therefore evident that the remixing effects due to the presence of bromate were much more drastic than in the case of those originally mixed in oxygen.

Experiments were now conducted to see what effects oxygen would produce during remixing after fermentation. Doughs with 20 mg. of bromate were mixed in air and then remixed after fermentation in nitrogen and oxygen. The results are given in Table IV, and figures for doughs containing 20 mg. of bromate remixed in air, obtained from Table II, are included for comparative purposes.

TABLE IV

LOAF VOLUME AND pH FOR DOUGHS WITH 20 MG. OF $KBrO_3$, MIXED 2 MINUTES IN AIR, THEN REMIXED AFTER FERMENTATION FOR VARYING TIME INTERVALS IN NITROGEN, AIR, AND OXYGEN

Dough time, 2 hours; pan proof time, 50 to 55 minutes; doughs mixed and remixed in Hobart-Swanson

| Remixing time | Loaf volume | pH of bread |
|---|---|---|
| *Min.* | *cc.* | |
| DOUGHS WITH 20 MG. BROMATE, REMIXED IN NITROGEN AFTER FERMENTATION | | |
| ½ | 1750 | 5.44 |
| 1 | 2040 | 5.43 |
| 1½ | 2250 | 5.43 |
| 2 | 2240 | 5.40 |
| 4 | 2220 | 5.40 |
| DOUGHS WITH 20 MG. BROMATE, REMIXED IN AIR AFTER FERMENTATION | | |
| ½ | 1720 | 5.43 |
| 1 | 2050 | — |
| 1½ | 2190 | 5.41 |
| 2 | 2230 | — |
| 4 | 2070 | 5.37 |
| DOUGHS WITH 20 MG. OF BROMATE, REMIXED IN OXYGEN AFTER FERMENTATION | | |
| ½ | 1750 | 5.40 |
| 1 | 1990 | 5.39 |
| 1½ | 2210 | 5.37 |
| 2 | 2090 | 5.43 |
| 4 | 1790 | 5.30 |

In the nitrogen remix series, the ½-minute loaf showed a very strong "excess bromate" effect, the 1-minute loaf was affected less, and the 1½, 2, and 4-minute loaves were about normal. In the air remix series, the loaves were similar to the nitrogen loaves, except for the one remixed 4 minutes, which showed an excess-remixing effect. In the oxygen remix series, the ½, 1, and 1½-minute loaves were similar to the corresponding nitrogen loaves, but the 2-minute loaf showed an excess-remixing effect and the 4-minute loaf a much stronger excess-remixing effect.

The volume figures in Table IV are shown graphically in Figure 3. Figure 4 shows photographs of the loaves remixed in oxygen and nitrogen. These results are just as striking as those obtained with different amounts of bromate.

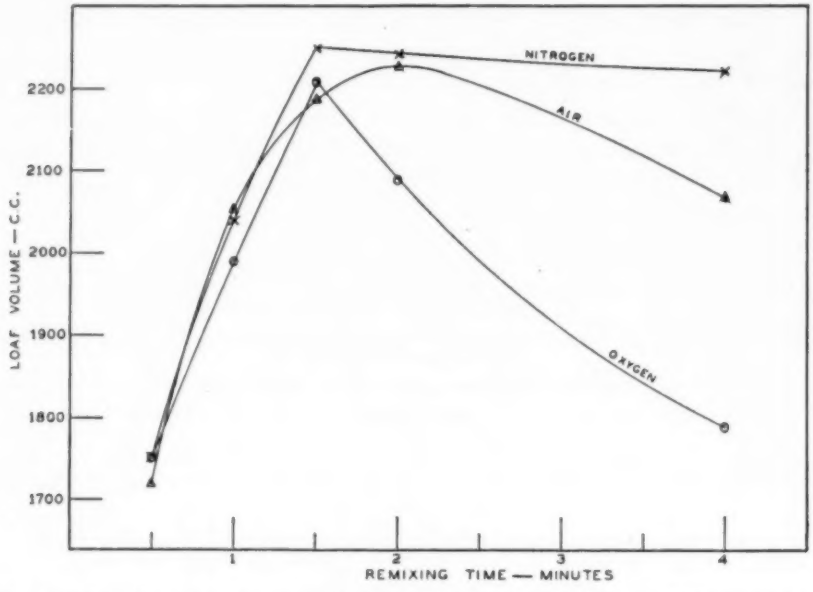


Fig. 3. Effects of variations in remixing time on doughs with 20 mg. of bromate, which were remixed after fermentation in nitrogen, air and oxygen.

1. It is apparent that oxygen plays a decisive role in the volume decreases produced by remixing doughs with bromate beyond the optimum; the absence of oxygen practically eliminates this decrease.

2. It is just as definitely indicated that the influence of oxygen on the sides of the curves approaching the optimum is very slight by comparison.

3. There was a decrease in pH due to remixing in all cases, but the change was definitely greater with oxygen than with nitrogen or air.

4. An excess-remixing effect in the bread, similar to that observed with 100 mg. of bromate and 4 minutes remixing in air, was obtained by remixing 4 minutes in oxygen with 20 mg. bromate. These excess-remixing effects, which resemble the familiar proteolytic effects of papain, are not due to protease action but accompany the physical and chemical changes produced by overmixing. We have been able to show differences in formol titration readings in bread showing proteolytic effects due to papain, but the effects due to overmixing produced no differences in formol titration.

Fig. 4. Photographs of loaves made from doughs with 20 mg. of bromate, showing effects of remixing after fermentation in oxygen and nitrogen, for varying time intervals.

An examination of Figures 1, 2, and 3, side by side, indicates that they all have an optimum loaf volume of roughly 2,200 cc. with a remixing time of 1½ to 2 minutes. The fact that this common point appears despite the different chemical treatment to which these doughs were subjected, and also the very marked changes in volume produced by as little as 30 seconds difference in remixing time, while approaching the optimum volume, suggest the hypothesis that the volume increases produced by remixing are due mainly to a physical change, perhaps a change in hydration or other colloidal properties of the dough. But

the decrease in volume beyond the optimum may be due to both physical and chemical changes. Evidence of chemical change is indicated by the differences in pH due to incorporated oxygen.

There are at least two practical applications indicated as a result of this work:

1. The production of bread from straight doughs may now be improved, in cases where poor results are obtained as a result of overfermentation. Given a sufficient amount of sugar in the dough, it may be fermented very much longer than usual and still produce good bread by being remixed for the proper time interval after fermentation.[1]

2. Short-time or "no dough time" bread may be made to resemble bread made in the usual way, by adding acid and oxidizing agent and mixing the dough in carbon dioxide.

## Summary

It was found that the undesirable effects produced by excessive amounts of bromate, or by prolonged fermentation with smaller amounts of bromate, could be eliminated by remixing the doughs after fermentation.

Variations in the remixing time produced great differences in the results obtained; after an optimum remixing time of 1½ to 2 minutes (in the Hobart-Swanson mixer at 110 r.p.m.), continued remixing produced decreases in loaf volume and bread quality which varied directly with the amount of bromate used in the dough.

The undesirable effects produced by excessive remixing of bromated doughs were found to be due in part to the incorporation of oxygen during remixing and were eliminated by replacing oxygen with another gas such as nitrogen.

It is suggested that the improvements in volume produced by remixing may be due mainly to a physical change in the colloidal properties of the dough.

[1] It has been found that doughs which have been overfermented may be put through the dough break a sufficient number of times, whereby they recover to the point where they will produce good bread. This may be an example of effects similar to those in which the "excess bromate" effect is overcome by the proper remixing interval after fermentation.

# DOUGH OXIDATION AND MIXING STUDIES

## III. THE EFFECTS OF PROTEASES AND REDUCING SUBSTANCES ON DOUGH WHEN MIXED IN OXYGEN

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(Read at the Annual Meeting, May 1938)

In the course of our work with different oxidizing agents, we had occasion to study the effects of oxygen gas on proteolytic activity in dough, and found that by mixing doughs in oxygen, proteolytic activity could be greatly inhibited. A short report on this work has been published (Freilich and Frey, 1937).

### Effects of Oxygen on Protease Activity

Table I and Figure 1 show the effects on proteolytic activity in dough of mixing increasing percentages of the flour in oxygen.

TABLE I

LOAF VOLUME OF DOUGHS WITH ADDED PAPAIN, AS AFFECTED BY MIXING VARYING PERCENTAGES OF THE FLOUR, WITH WATER, IN OXYGEN [1]

| | Loaf volume |
|---|---|
| | *cc.* |
| Papain, not treated | 1730 |
| Papain alone treated with oxygen | 1780 |
| 12½% of the flour, mixed in oxygen | 1810 |
| 25% of the flour, mixed in oxygen | 1860 |
| 50% of the flour, mixed in oxygen | 1940 |
| 75% of the flour, mixed in oxygen | 1980 |
| 100% of the flour, mixed in oxygen | 2100 |

[1] After the oxygen treatment, the papain and the balance of the dough ingredients were added and the mixing completed in an atmosphere of nitrogen. (Figure 6, Dough Oxidation and Mixing Studies I, shows the Hobart-Swanson, as used for mixing dough in oxygen and nitrogen.)

There was a progressive increase in loaf volume and decrease in the proteolytic effect of the added papain with increasing percentages of oxygenated flour, but the treatment of papain alone with oxygen produced no significant decrease in proteolytic activity.[1]

### Effects of Oxygen on Reducing Substances

The effects of wheat germ, cysteine, and glutathione are also greatly inhibited by mixing in oxygen, as shown by Table II. Figure 2 shows the effects of oxygen on wheat germ in dough.

The loaves made from the doughs which were mixed in nitrogen

[1] To produce the mixing effects described in this paper a high-speed mixer has been found preferable, though similar results may be obtained by longer mixing in low-speed mixers.

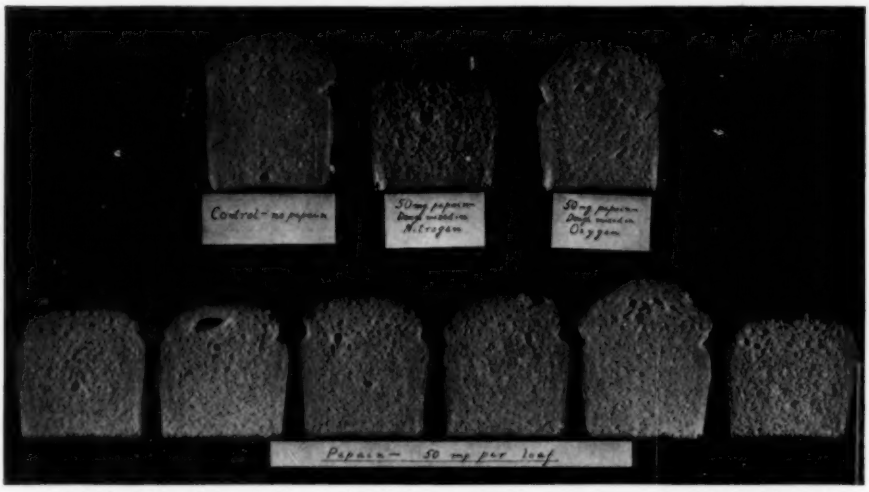


Fig. 1. Effect of oxygen on proteolytic activity in dough. Bottom row shows effects of treating increasing amounts of the flour in water alone (without papain); from left to right the amounts of flour treated with oxygen were 12½%, 25%, 50%, 75%, 100%; the loaf on the extreme right shows that when the papain alone was treated with oxygen outside of the dough, in water solution, its activity was not noticeably affected.

## TABLE II

LOAF VOLUME OF DOUGHS WITH WHEAT, GERM, CYSTEINE, AND GLUTATHIONE

Doughs mixed in nitrogen and oxygen

| | Loaf volume |
|---|---|
| | *cc.* |
| Control | 2100 |
| Wheat germ 3%, dough mixed in nitrogen | 1900 |
| Wheat germ 3%, dough mixed in oxygen | 2140 |
| Cysteine-hydrochloride 75 mg., dough mixed in nitrogen | 1850 |
| Cysteine-hydrochloride 75 mg., dough mixed in oxygen | 2040 |
| Glutathione 50 mg., dough mixed in nitrogen | 1770 |
| Glutathione 50 mg., dough mixed in oxygen | 2150 |

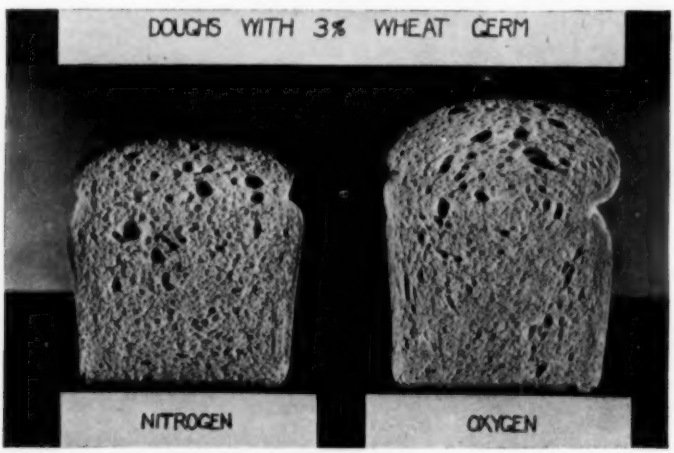


Fig. 2. Effects of mixing in oxygen on dough containing added wheat germ.

showed very strong effects of the proteolytic type, but these effects were almost completely eliminated by mixing the doughs in oxygen. Whether these effects are due to true proteolysis alone remains to be determined.

It should be pointed out that although papain, cysteine, and glutathione apparently produce very similar bread characteristics, their effects in dough are quite different. Cysteine and glutathione produce immediate, specific effects, which are noticeable while the dough is still being mixed. But the effects of papain are very gradual by comparison; doughs with added papain, in amounts which produce effects in bread similar to those of cysteine and glutathione, may be normal after mixing and become soft and sticky only after a few hours of fermentation. Balls and Hale (1936) have made similar observations on the specificity of the effects of cysteine on gluten.

### Effects of Oxygen with Different Types and Grades of Flour

The improvements noted above were obtained with doughs to which wheat germ, cysteine and glutathione and excessive amounts of protease, were added, in order to magnify the differences produced by mixing in oxygen.

TABLE III

LOAF VOLUME OF BREAD MADE FROM DIFFERENT TYPES OF FLOUR—DOUGHS MIXED IN NITROGEN, AIR AND OXYGEN

Mixing time, 2 min. in Hobart-Swanson

| | Loaf volume |
|---|---|
| | *cc.* |
| NORTHWESTERN SPRING STRAIGHT FLOUR | |
| Dough mixed in nitrogen | 1970 |
| Dough mixed in air | 1980 |
| Dough mixed in oxygen | 2120 |
| Dough mixed in oxygen [1] | 2120 |
| NORTHWESTERN BAKER'S FLOUR, TYPICAL SPRING WHEAT | |
| Dough mixed in nitrogen | 2010 |
| Dough mixed in air | 2050 |
| Dough mixed in oxygen | 2080 |
| Dough mixed in oxygen [1] | 2100 |
| SHORT PATENT, SPRING WHEAT FLOUR | |
| Dough mixed in nitrogen | 2050 |
| Dough mixed in air | 2050 |
| Dough mixed in oxygen | 2030 |
| Dough mixed in oxygen [1] | 2040 |

[1] Dough was kept in mixer in an atmosphere of oxygen for a total of 5 minutes, but the mixing was broken up into four 30-second intervals, with three 1-minute rest periods in between, in order to prolong the oxygen treatment without changing the mixing time of 2 minutes.

Experiments were also conducted with different types and grades of flour, in order to see how far their baking quality could be improved by mixing in oxygen and to compare such improvements with those obtained when making deliberate changes in baking quality by additions of papain or wheat germ. In Table III and Figure 3 are shown loaf volumes and photographs of bread made from different types of flour and mixed in nitrogen, air, and oxygen.

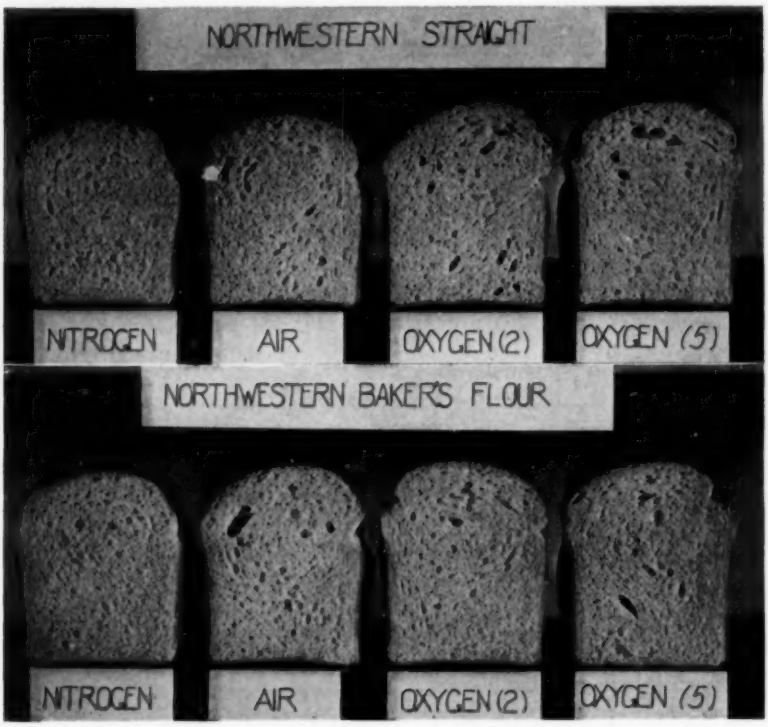


Fig. 3. Flour mixed with increasing amounts of oxygen; last loaf treated with oxygen 5 min., as explained at bottom of Table III.

Mixing with increasing amounts of oxygen produced progressive and decided improvements in the texture and also the crumb color of bread from the Spring Straight and the Northwestern Baker's flour; distinct improvement in volume was obtained with both flours but was greater with the Spring Straight. There were no improvements in volume or texture with the short patent, but a distinct improvement in crumb color was apparent.

In Table IV and Figure 4 are shown loaf volumes and photographs of bread made from the different fractions of flour milled from a good grade of Texas wheat.

TABLE IV

LOAF VOLUME OF BREAD MADE FROM THE DIFFERENT FRACTIONS OF FLOUR MILLED FROM THE SAME WHEAT—A GOOD GRADE, HIGH PROTEIN, TEXAS WHEAT

Doughs mixed in nitrogen, air, and oxygen; mixing time 2 min., in Hobart-Swanson

| | Loaf volume |
|---|---|
| | *cc.* |
| 100% EXTRACTION FLOUR | |
| Dough mixed in nitrogen | 2000 |
| Dough mixed in air | 2000 |
| Dough mixed in oxygen | 2070 |
| Dough mixed in oxygen [1] | 2100 |
| PATENT FLOUR | |
| Dough mixed in nitrogen | 1870 |
| Dough mixed in air | 1980 |
| Dough mixed in oxygen | 2010 |
| Dough mixed in oxygen [1] | 1980 |
| FIRST CLEAR FLOUR | |
| Dough mixed in nitrogen | 1700 |
| Dough mixed in air | 1820 |
| Dough mixed in oxygen | 1920 |
| Dough mixed in oxygen [1] | 1910 |
| SECOND CLEAR FLOUR | |
| Dough mixed in nitrogen | 1690 |
| Dough mixed in air | 1810 |
| Dough mixed in oxygen | 1930 |
| Dough mixed in oxygen [1] | 1980 |

[1] Dough was kept in mixer in an atmosphere of oxygen for a total of 5 minutes, but the mixing was broken up into four 30-second intervals, with three 1-minute rest periods in between, in order to prolong the oxygen treatment without changing the mixing time of 2 minutes.

Mixing the doughs with increasing amounts of oxygen produced distinct improvements in volume and great improvements in texture and crumb color with the 100% extraction and the patent flours. But the improvements were even greater with the first and second clear flours; the loaves produced by mixing in nitrogen and air from these flours were poor in volume, color, and texture, and decidedly unsatisfactory, but the loaves produced by mixing in oxygen were very much better in all respects, and the textures were practically normal.

It is evident that the lower the grade of the flour, the greater is the improvement produced by mixing in oxygen. The improvements with the first and second clear flours are comparable in magnitude to the differences obtained when adding papain or wheat germ to the dough and mixing in oxygen.

In Figure 5 are shown loaves made from the second clear flour used above; a commercial type formula, including malt extract and powdered milk, was used; the small loaf was mixed in nitrogen, and its volume was 1,910 cc.; the large loaf, with a volume of 2,130 cc., was mixed in oxygen; the great improvement produced by oxygen is quite apparent.

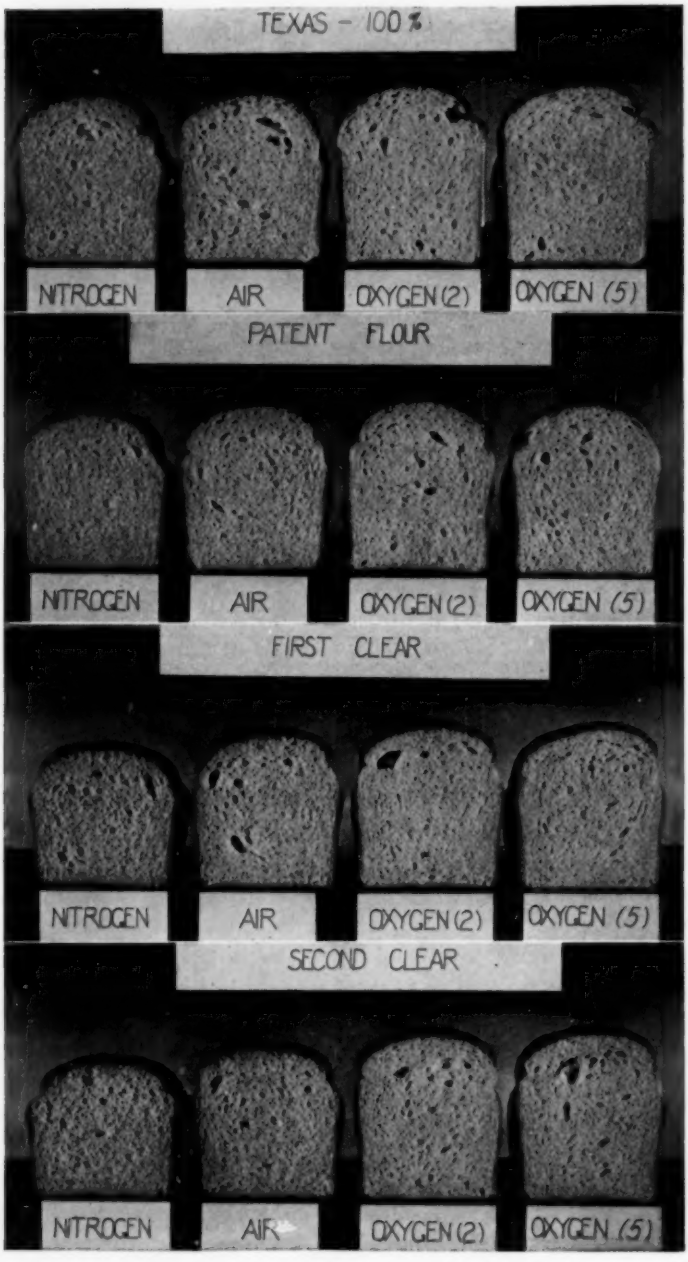


Fig. 4. Loaves made from the same Texas wheat. Flours mixed with increasing amounts of oxygen.

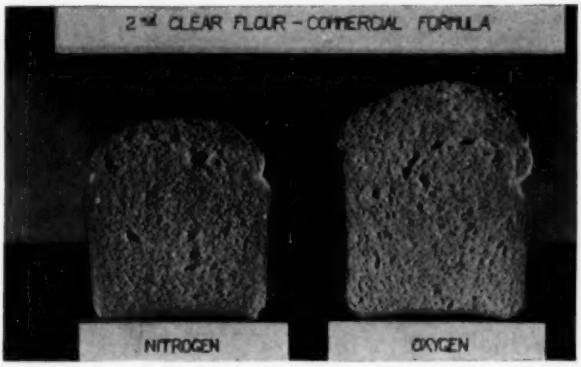


Fig. 5. Effects of oxygen on 2nd clear flour in a commercial formula.

## Formol Titration Experiments

We have seen that the activity of added papain is greatly retarded by mixing doughs in oxygen and also that definite improvements in bread quality are obtained by mixing doughs from different flours in oxygen. To determine whether these improvements may be due, at least in part, to the inhibition of the activity of native protease present in flour, we made formol titrations on extracts of bread made from doughs which were allowed to stand for different time intervals, after mixing in oxygen and nitrogen, with and without added papain. Patent flour was used. We assumed that increases in the amount of formol nitrogen were due to proteolytic activity. The results are shown in Table V.

TABLE V

FORMOL TITRATION RESULTS, WITH BREAD EXTRACTS FROM DOUGHS WITH AND WITHOUT PAPAIN, MIXED IN NITROGEN AND OXYGEN [1]

| | Formol *N* [2] (cc. *n*/200 NaOH per 25 cc. bread extract) | | Increase in formol *N* (cc. *n*/200 NaOH) |
|---|---|---|---|
| | ¼-hr. dough | 18-hr. dough | |
| Control, mixed in oxygen | 3.1 | 4.2 | 1.1 |
| Control, mixed in nitrogen | 3.4 | 5.95 | 2.55 |
| Papain, 50 mg. mixed in oxygen | 4.9 | 7.6 | 2.7 |
| Papain, 50 mg. mixed in nitrogen | 5.45 | 17.1 | 11.65 |

[1] Ninety percent of the flour and all other ingredients except the yeast were made into doughs and allowed to stand for ¼ hr. or 18 hrs., then they were remixed with 3% yeast, the balance of flour and water, allowed to stand for a few minutes, then rounded, proofed and baked.

[2] Method for formol titration: To 50 g. bread crumb, added 150 cc. water, stirred, centrifuged, and used 25 cc. portions of the liquid for formol titration as in the usual procedure, but with the following modifications: used *n*/200 NaOH, and electrometric titration with glass electrode to obtain better end point than with phenolphthalein; titration error, ±0.1 cc.

These results show a great increase in formol N due to papain and a definite increase in the doughs without papain. These increases were greatly reduced by mixing in oxygen. This indicates that (*a*) doughs made with patent flour show evidence of proteolytic activity, and (*b*) this activity is greatly retarded by mixing the doughs in oxygen.

## Discussion

There has been some discussion regarding the explanation of the improvements produced in bread making by the use of oxidizing agents such as potassium bromate (Jørgensen 1935; Read and Haas 1937). In view of the inhibition by bromate and by oxygen of the effects of papain and the inhibition by oxygen of the production of formol N in dough, it is not illogical to ascribe the improvements produced by oxidation, at least in part, to the inhibition of protease activity in dough.

But if the effect of bromate were merely to inhibit protease activity and nothing more, then there should be no further effects, after an amount of bromate sufficient to accomplish this purpose has been added. However, it is evident from some of our work that the effects of bromate and other oxidants are not confined simply to inhibition of proteases—both added and those present in the flour—but are far more profound, as indicated in Section I of this series. These latter effects must also be taken into account in seeking an explanation of the effects of oxidation in dough. It remains to be established to what extent these and perhaps other factors are effective under ordinary conditions of bread making.

The inhibition of proteolytic activity by oxygen incorporated into dough during mixing is an effect very much like that of bromate in the presence of added papain; our work with oxygen seems to indicate action on some flour constituent rather than direct action on the enzyme by oxygen.

The improvements produced by oxygen with different flours, particularly lower-grade flours, may be due not only to inhibition of protease activity, but also to oxidation of reducing substances, such as glutathione. Our results and those of Balls and Hale (1936) show that cysteine and glutathione produce very harmful effects in bread, and Sullivan, Howe, and Schmalz (1936) have shown the presence of glutathione in wheat germ. We have shown that the harmful effects produced by additions of cysteine, glutathione, and wheat germ were partly overcome by mixing the doughs in oxygen. The lower the grade of flour, the greater is the concentration of protease and germ fractions in it; consequently the improvement produced by oxygen is

greater. But the improvement produced by oxygen even with normal bread flours is by no means negligible, and may be explained on the same basis.

It has been shown that oxygen produced both detrimental and good effects in bread making, and it may be well to point out that there is no contradiction involved, since the conditions under which these effects were obtained were entirely different. The detrimental effects [2] were produced by too much remixing, after fermentation, in doughs containing bromate; the good effects were obtained in doughs without bromate, which were originally mixed in oxygen and not remixed after fermentation.

The following brief description may give a more coherent picture of the relationships involved in the results of the work presented in these papers. The addition of protease or glutathione to a dough, which would ordinarily give a normal loaf of bread, produces bread of low volume and poor quality. The effects of protease or glutathione may be overcome and normal bread again obtained by adding the proper amount of oxidizing agent such as $KBrO_3$, or by mixing the dough in oxygen. The addition of too much bromate, however, produces a poor loaf, showing the "excess bromate" effect. This in turn is overcome and normal bread obtained by remixing the dough for the proper time interval after fermentation. But too much remixing in air or oxygen breaks down the dough and gives poor bread. By replacing the air or oxygen with another gas such as nitrogen, the effects of excessive remixing may also be overcome, and normal bread again obtained. This is shown diagrammatically, in Figure 6.

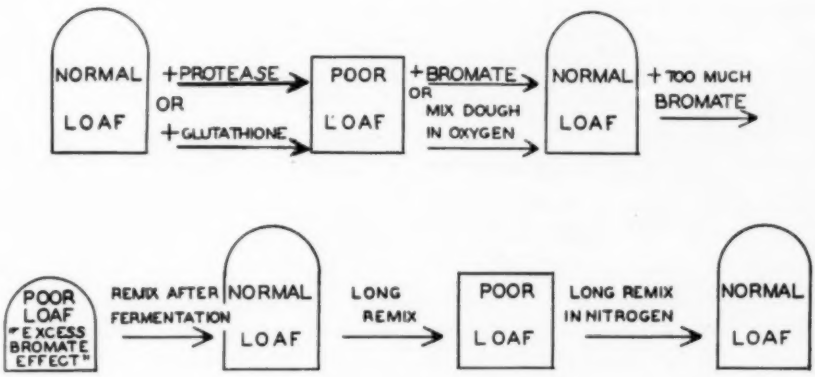


Fig. 6. . Diagrammatic representation of interrelationships of oxidation and mixing in bread doughs.

[2] Dough Oxidation and Mixing Studies II.

The importance of these observations on the effects of oxygen may not be confined entirely to the baking field. It may find application in studies on the germination of seeds, reactions in normal and abnormal animal tissue such as cancer cells, proteolytic action of bacteria and molds, and the autolysis of tissues.

## Summary

The effects of papain in dough were greatly retarded by mixing the dough in oxygen.

The effects of oxygen were found to be due to its action on the flour, and not to any direct action on the papain.

The effects of wheat germ, cysteine, and glutathione were greatly retarded by mixing in oxygen.

Great improvements in volume, color, and texture were produced by mixing doughs from different types of flour in oxygen; the greatest improvements were obtained with the lower grades, such as first and second clear flours.

The production of formol N in doughs made from regular white bread flour was markedly retarded by mixing the doughs in oxygen.

### Acknowledgment

We wish to acknowledge the assistance and advice of Dr. Quick Landis.

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# A METHOD AND APPARATUS FOR TESTING DOUGHS

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Wallace & Tiernan Co., Newark, N. J.

(Read at the Annual Meeting, May 1938)

During one of the investigations in this laboratory an attempt was made to produce crustless bread. It appeared probable that internal heating of the dough should produce such bread. Heat can be generated internally by using the dough as the resistance between electrodes which are carrying alternating current. By this method crustless bread was produced which had a thin skin on all exposed areas. The final bread appears nearly as though the crust had been cut away from a sandwich loaf. This method of making bread made it appear possible to test the properties of the dough during proofing and baking. Loaf volume can be measured during oven spring by observing the rise of a pointer supported on a light disc resting on the top of the dough. The resistance to the movement of a plunger through dough can be measured by having a pointer attached to a weight and following its progress as it sinks into the dough during baking. The downward movement of a plunger in a loaf during baking is complicated by the upward movement of the dough due to oven spring. This carries the plunger in an opposite direction, thus requiring a rather elaborate method of correction so as to arrive at a true picture of the plunger's passage through the dough. The indications of the plunger cease during dough thickening so that no further information regarding the character of dough is obtained.

In order to cook a dough and have a controlled rate of temperature rise in the dough while these tests are being carried on, it is desirable that the heat input into the dough be constant at all times throughout the cooking. This result can be accomplished by applying a constant wattage to the dough, using a watt meter and a variometer for control. Also a volt meter can be placed in the line and the significance of variation in electrical resistance of the dough can be gained by reading the changes in voltage that are required to keep a constant wattage flowing through the dough, thus giving an additional test indicating the conductivity of the dough while baking.

If one could measure the pressure in the cellular structure of dough while proofing and baking, that measurement should indicate the stress which the dough is under at any particular moment. It was found that the pressure within the dough can be measured during these bakings by forming a small chamber of relatively large area underneath the dough, which is sealed around the edges to avoid leaks, and which

communicates to a manometer of fine bore. Under this condition the gases in the dough diffuse into this chamber and build up a pressure which is in equilibrium with the pressure within the dough. To produce this pressure the transfer of only a small amount of gas is required. The sensitivity of the method is evidenced by the pressure responding at once to changes in the rate of heating. Also the reading drops to zero immediately upon cutting off the heat, thus showing that the pressure within the chamber is in equilibrium with the pressure within the dough. The chamber is constructed of a fine-mesh metal screen which is insulated by a proper coating and is further covered with a thin layer of glass wool. The glass wool gives better insulation and more reproducible pressure changes.

The complete device is shown by Chart I in two sectional views.

CHART I

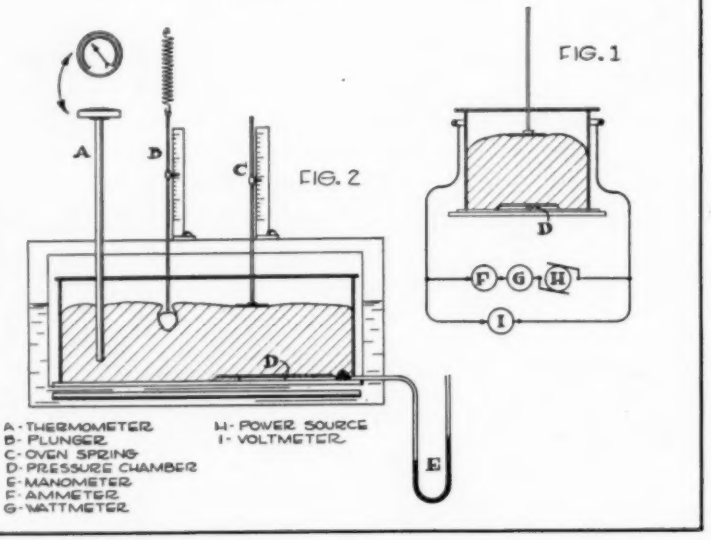



Figure 1 gives an end view cross-section of the baking pan showing the insulated bottom and the electrodes on the sides with electrical connections for carrying the current. The electrical instruments in the circuit and the float for loaf volume are shown. Underneath the dough is the flat pressure chamber formed by a screen and glass wool with a small-bore pipe leading out to a manometer, which is shown in the side view in Figure 2. In order to avoid condensation of moisture on the inner side of the walls of the pan as heat is generated in the

dough, it is desirable to either insulate [1] or keep the pan at a slightly elevated temperature above that within the dough. This latter is accomplished by placing the pan in a chamber which is heated. The chamber can be heated to approximately the boiling point of water without introducing any serious error into the readings, but it is more desirable that the chamber be heated progressively as the dough is heated but more rapidly, so that a small transfer of heat to the pan occurs to prevent condensation on the walls.

The various measuring instruments are shown in their position. Readings are taken regularly, as nearly simultaneously as possible, so that the records will show all properties of the dough at the same instant.

It is desirable to heat at approximately the same rate as a loaf of bread is heated in the oven. Of course, one must recognize that the result of heating dough interiorly is different from that which takes place in the commercial baking of bread, where the heat rise progresses from the outside to the inside. However, each portion of the dough in crust bread must go through a similar cycle of heating as does the dough in the electric pan. Thus the reactions which are observed in the electric pan can be construed to have occurred in any one portion of a commercial loaf, the main difference between the two baking methods being the rate at which the reactions happen respectively in the different zones and the effect of these reactions upon each other.

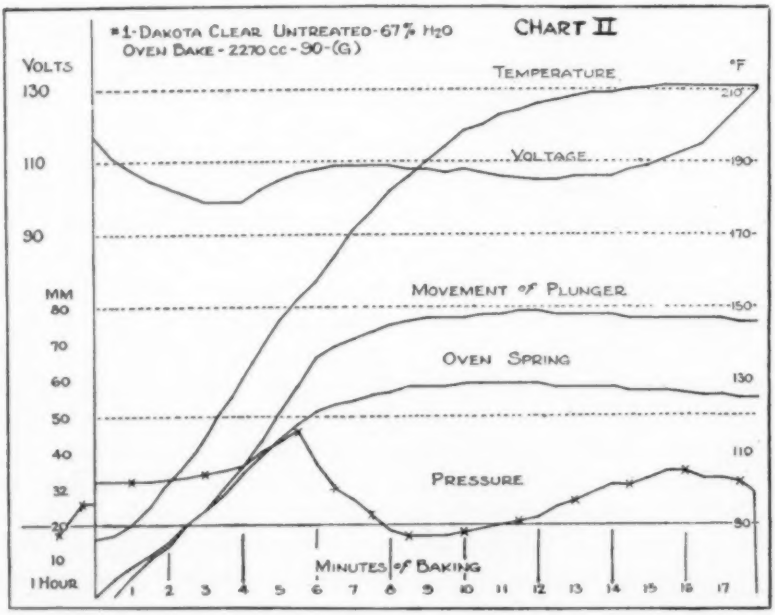
It is to be noted that the plunger has a spring attached to it, so that as it sinks through the dough its effective weight is reduced. The use of the spring was found desirable to enable one plunger to operate properly in all characters of dough. A weight which would sink slowly through a soft-wheat dough would not penetrate a strong hard-wheat dough, and *vice versa* a weight which would penetrate a strong dough would sink immediately to the bottom in a soft dough. By supporting the weight with a spring so that its effective weight becomes less as it sinks, its application can be made universal and the results made comparable. However, it has been found in practice that the use of the plunger in conjunction with the use of the pressure chamber on the same dough presents some undesirable features because the penetration of the plunger into the dough during the oven spring affects the pressure within the dough and interferes with correct readings in the pressure chamber; hence in many instances it is desirable that these readings be taken separately on duplicate doughs of the same kind. It has also been found difficult to duplicate plunger readings. Further changes in this feature are being made. The results of all the readings

[1] The construction and technique of using an insulated pan will be further described in a later publication.

are plotted on one chart with time as the base (or abscissa) and the movement or pressure in millimeters as the ordinate. In the electric measurements, the voltage of the current is the ordinate. On the chart one can then see the record of any or all of these properties at the same instant, as well as follow their progress during the course of baking.

To start the operations the dough is handled as usual and proofed in the electric pan in the proof box in the regular way. The manometer is attached to the pressure chamber while proofing so that the pressure of proofing can be read. When standard proof height is reached the pan is transferred, with manometer still attached, to the testing chamber where the thermometer is inserted in the dough and the loaf volume float is set in position on the dough and the plunger lowered to the dough surface. The current is then turned on and the plunger released simultaneously and all readings taken immediately and continued at regular intervals until 212° F. or the highest voltage available is reached, when the test is discontinued.

Chart II gives the results obtained on a freshly milled flour using 540 grams of dough in a 4½ × 9-inch pan, and shows how the various measurements are recorded so their relation to each other can be seen at any moment during the baking process.



**Summary**

A method has been shown for baking doughs by making them the resistant unit between electrodes carrying alternating current.

Means are also shown for determining the voltage required to keep a constant wattage flowing through the dough, the rate of temperature rise produced by the heat generated from the current, and the rate the dough rises as the heat is generated. Special means are shown for determining the rate at which a heavy plunger will pass downward through the dough while oven spring is occurring. Also, special means are shown for determining the pressure within the dough throughout the entire baking period.

By preventing evaporation, the formation of a crust is avoided and the properties determined are those produced by the dough itself independent of the influence of a crust.

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## EFFECT OF TEMPERATURE ON DOUGH PROPERTIES, I

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(Read at the Annual Meeting, May 1938)

A method and apparatus for testing the properties of bread dough while being baked by internal heating, as described by Baker in the previous paper, has been tested by us to obtain some idea of its significance and application. The method indicates the temperature rise of dough during baking, the voltages applied to maintain a predetermined wattage within the dough, the fall of a plunger through the dough while baking, the gas pressures generated within the dough, and the oven spring. These values can be obtained simultaneously, so that their relation can be readily noted. They will be discussed separately and then in combination.

Chart 1 shows the rise of temperature at the center of the loaf while being baked with heat generated from 200 watts passing through 540 grams of dough in a pan 4½ × 9 inches. The uniform generation of heat within a substance which undergoes no chemical or physical change should cause a regular increase in temperature if no heat were added or subtracted. Such a temperature curve when plotted against time would be substantially a straight line. Any deviation from a straight line in such heating of dough indicates absorption of heat by some physical or chemical change in the dough mass. It will be seen that fermented dough, while heating at a uniform heat input, does not warm with a uniform temperature gradient (Bailey and Munz, 1938),

there being periods where there is a slower temperature rise than at other times, indicating an increased absorption of heat during these periods. There is a noticeable absorption of energy at the beginning of the heating period, which continues up to about 118° to 120° F. This heat absorption is believed to be due to carbon dioxide coming out of solution in the dough and from any loosely bound chemical combination it may have with the dough ingredients. The temperature then climbs more rapidly until approximately 130° F. is reached, after which the rise is slightly less. This change coincides with starch swelling and may be due to that reaction. The rate then continues uniformly until about 175° F. is reached, where there is further absorption of heat which becomes progressively greater until the end of the heating at 212° F. The large heat absorption toward the end of the cooking period is believed to be due primarily to the evaporation of alcohol and water. It is apparent that alcohol acts as a buffer to temperature rise in a dough, interfering with its approach to the boiling point of water. This helps explain why commercially baked bread does not reach 212° F. in the interior of the loaf (Bailey and Munz, 1938).

The effect of alcohol evaporation on the temperature curve is greater than that of carbon dioxide, as one would expect, because of its larger amount (Blish and Hughes, 1932), liquid state, and greater solubility in the dough. The temperature curve offers the interesting suggestion that there are two sources of pressure in a loaf during baking. Alcohol vapor is available in greater potential volume than carbon dioxide and exerts its pressure after the temperature of the dough exceeds the boiling point of alcohol. The significance of this will be considered later in connection with pressure studies.

Chart 1 also shows the voltages which were required to maintain a current of 200 watts in the dough during the entire period of cooking. During the heating of bread dough the voltage drops while the dough warms to approximately 120° F.,[1] when its downward course ceases and the voltage rises rather sharply as the dough warms until between 145° and 165° F. is reached. The swelling temperatures of wheat starch (Dedek, Jelinek, and Kulcickyj, 1936; Cook and Axtmayer, 1937) and the setting range of dough occur during this voltage rise, suggesting that here water is being taken up by the starch. The voltage now remains substantially at a constant level for a sustained period, when a furher marked rise occurs to the end of the experiment. It is not possible to continue the current after 212° F. is reached, as

[1] It has subsequently been found that under the conditions of these experiments the temperature of the dough was not uniform, being warmer near the electrodes due to local resistance at the electrode surface. Also a thermometer follows the temperature of a rapidly heating body with an appreciable lag. Subsequent work in which these errors are largely eliminated shows that this phenomenon occurs at 130° F. or higher.

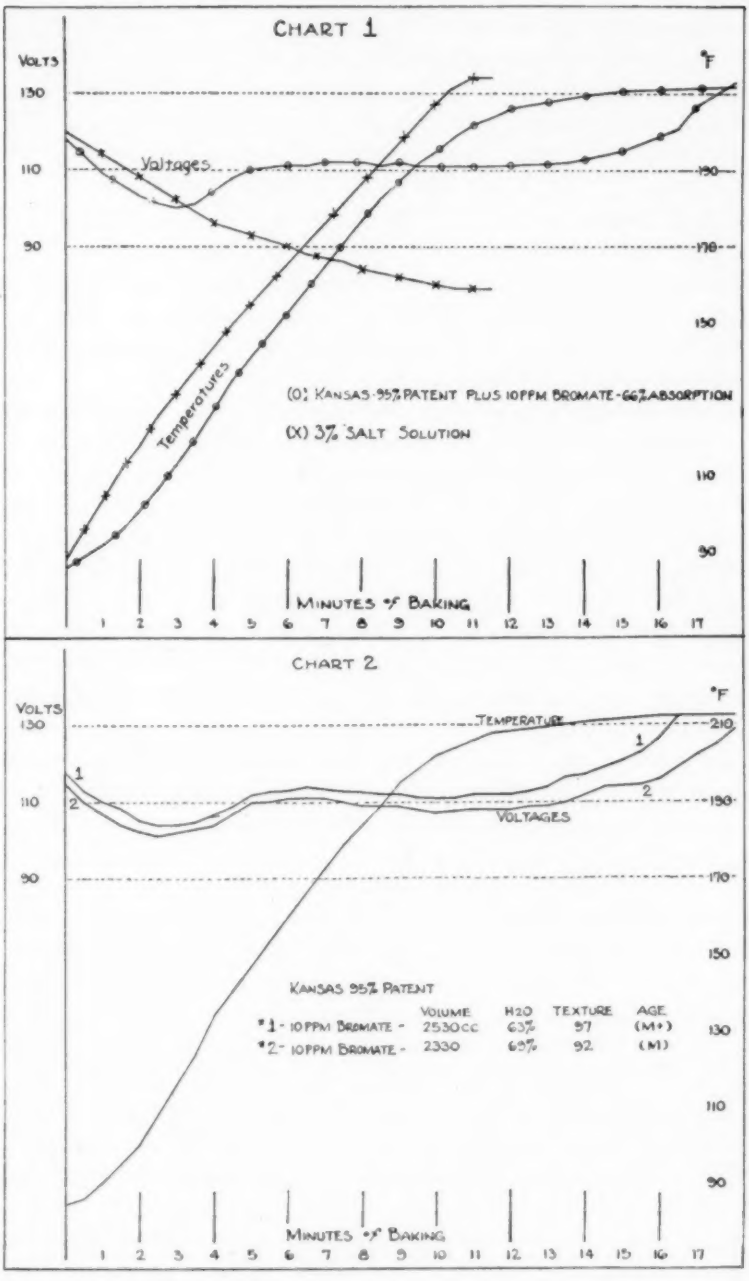


CHART 1
VOLTS
130
110
90
°F
210
190
170
150
110
90
Voltages
Temperatures
(O) KANSAS 95% PATENT PLUS 10PPM BROMATE - 66% ABSORPTION
(X) 3% SALT SOLUTION
MINUTES of BAKING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
CHART 2
VOLTS
130
110
90
°F
210
190
170
150
130
110
90
TEMPERATURE
VOLTAGES
1
2
KANSAS 95% PATENT
VOLUME H2O TEXTURE AGE
*1 - 10PPM BROMATE - 2530cc 63% 97 (M+)
*2 - 10PPM BROMATE - 2330 68% 92 (M)
MINUTES of BAKING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

evaporation of water occurs at the electrode surface and rapidly builds up resistance in the circuit. A maximum of 130 volts was usually sufficient to raise the dough to approximately 212° F.

The voltage changes and temperature rise of a 3% salt solution heated in the same manner as is the dough are also shown. This is not a straight line, as adiabatic conditions were not maintained during the heating.

Chart 2 shows the effect upon the voltage of changing the absorption water in the dough by 6%. Of the two voltage curves given, the one with the lower voltage is for the higher absorption, namely 69%, and the one with the higher voltage is for the 63% absorption, indicating that the voltage level is controlled by the dough's conductivity; thus less water, higher resistance.

Chart 3 shows the voltage curves where the doughs being baked received different degrees of oxidation with potassium bromate. The higher treatments cause the final voltages to rise sooner than the lower treatments, suggesting that the bromate treatment accelerates some reaction in the dough that increases its electrical resistance.

A most striking thing about these curves is the shift in the final voltage rise; this rise occurs at a lower temperature for every increment of bromate, until the highest treatment of bromate has caused the start of the rise to change from 210° F. to approximately 160° F. Apparently this increase in resistance of the dough occurs independently of alcohol evaporation. In view of the fact that the starch has largely swollen prior to this rise, it would appear likely that some reaction of the gluten or some electrode phenomenon might also account for such a large increase in voltage. Further investigations on this point are under way.

Chart 4 shows the voltage and temperature curves for starch and gluten separately heated in 3% salt solution in the same manner as described for dough. The starch was prepared by washing it from the dough with a 3% brine, centrifuging the starch from the brine, and packing the moist starch into a cell between electrodes. This gives a concentration of starch slightly higher than is obtained in commercial doughs. The gluten from this washing was collected, and after removal of all the excess brine, was packed in a cell in a similar manner. This gluten was necessarily more concentrated than in doughs. The voltage and temperature changes were then noted while the current was applied.

While the starch was heating a drop in voltage occurred, followed by a rise during the period of thickening, similar to the behavior of dough. After the thickening of the starch had solidified the mass, the voltage for the starch resumed its downward course as does the

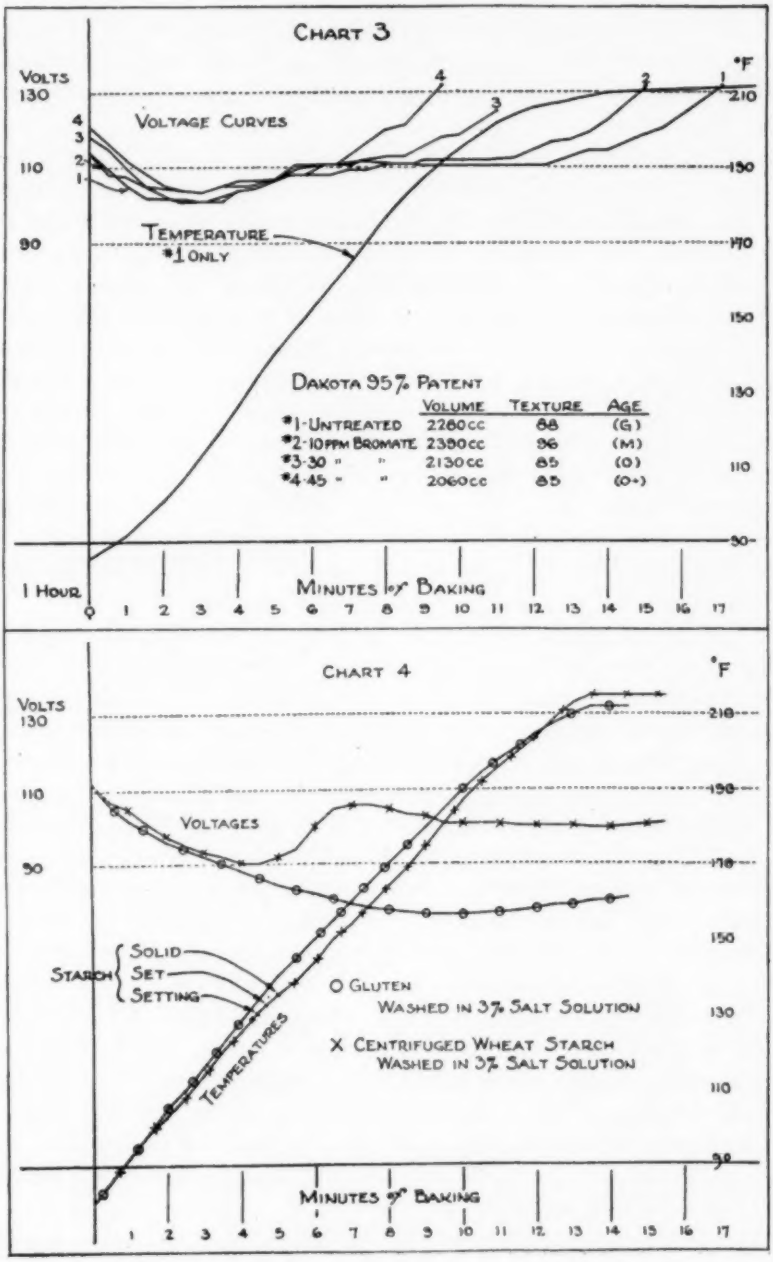


CHART 3
VOLTS
130
110
90
°F
210
190
170
150
130
110
90
VOLTAGE CURVES
TEMPERATURE
*1 ONLY
DAKOTA 95% PATENT
VOLUME TEXTURE AGE
*1-UNTREATED 2280cc 88 (G)
*2-10 PPM BROMATE 2380cc 96 (M)
*3-30 " " 2130cc 85 (O)
*4-45 " " 2060cc 85 (O+)
1 HOUR
MINUTES OF BAKING
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
CHART 4
VOLTS
130
110
90
°F
210
190
170
150
130
110
90
VOLTAGES
STARCH
SOLID
SET
SETTING
TEMPERATURES
O GLUTEN
WASHED IN 3% SALT SOLUTION
X CENTRIFUGED WHEAT STARCH
WASHED IN 3% SALT SOLUTION
MINUTES OF BAKING
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

salt solution. The temperature rise of the starch is fairly regular throughout the entire course of the heating to 212° F. The voltage required to heat gluten behaves at first in a similar manner to the salt solution but later drops less rapidly, indicating some reaction in which heat is absorbed.

Chart 5 shows the progress of the plunger through doughs while cooking. The weight at first sinks at a moderate rate. As the dough springs upward, however, the weight penetrates more easily and falls very rapidly just prior to the period of starch swelling. Upon the dough becoming thick around 150° F. the plunger's further motion is almost completely arrested. The period of very rapid motion may be due in part to a softening of the dough (Bailey and Munz, 1938) but is probably also influenced by the decrease in density of the dough due to oven spring and by the approach of the dough cell walls to the limit of their tensile strength, making them more readily broken by the additional strain furnished by the moving weight. This is always the character of the plunger's motion except in unoxidized doughs from freshly milled flours or weak flours. In these cases the weight will plunge to the bottom of the dough very rapidly with little alteration of its speed.

Plunger measurements are not included in the remaining charts as their duplication has been found somewhat difficult and our technique is not considered to have reached a stage where we can rely upon this measurement. Further improvement of this technique is under way.

Chart 6 shows the results obtained from measuring the pressure in the chamber under the loaf during proofing and baking. The weight of dough above the pressure chamber, with 540 g. of dough spread over a pan 4½ × 9 inches is such that it will require a pressure of approximately 20 mm. of oil of 0.85 density to overcome the weight of the dough. This will be referred to in this paper as the "hydrostatic pressure" and is indicated by a black line across the bottom of the chart at the 20-mm. position.

The charts also have a vertical line separating the first major division from the latter portion of the chart. This first division represents one hour of time and is used to record the pressures obtained during proofing. The remainder of the chart is divided into 2-minute divisions for each corresponding section, so that the entire chart from this point covers a period of 18 minutes,[2] during which the baking of the loaf is carried to 212° F.

While proofing, the pressure in the dough rises until nearly a constant level is obtained during the last 15 minutes. This is usually somewhere between 22 and 30 mm. of oil, and indicates the force

[2] The time of heating can be varied to suit the experimenter by altering the wattage.

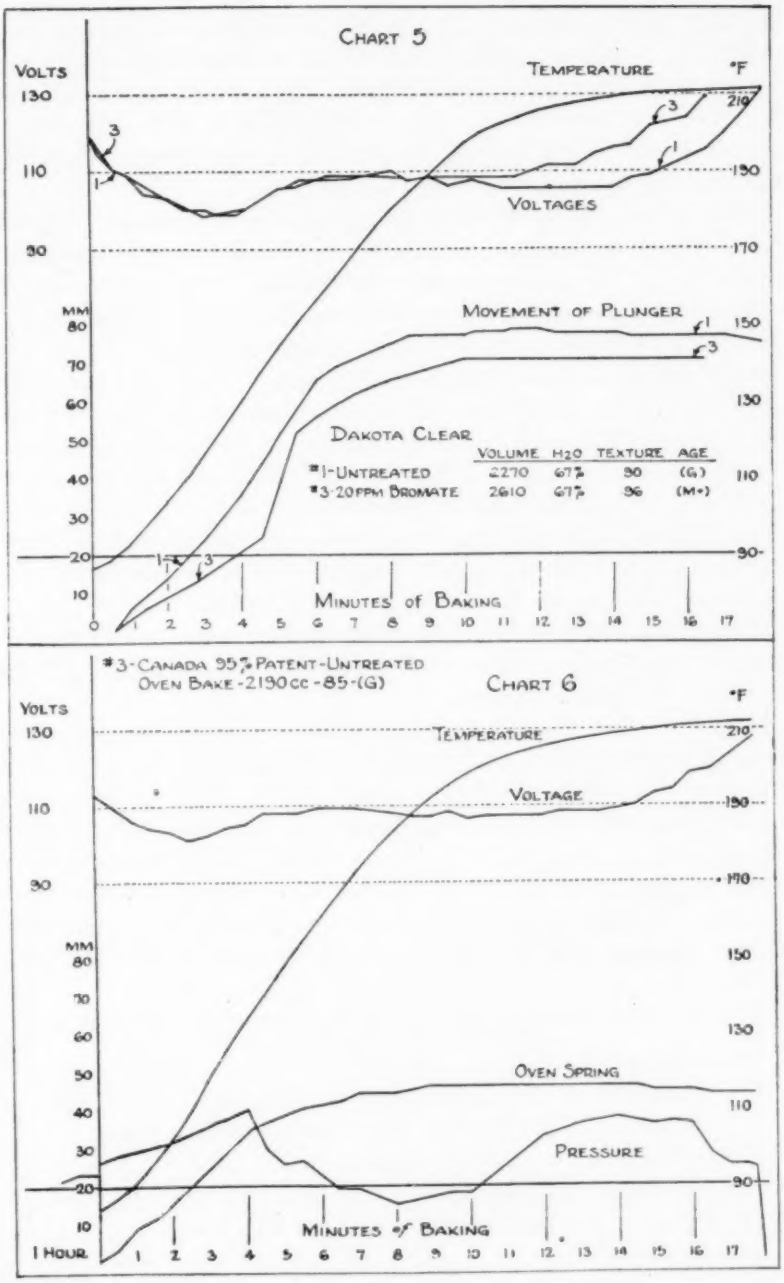


CHART 5
VOLTS
130
110
90
TEMPERATURE
°F
210
190
170
VOLTAGES
MM
80
70
60
50
40
30
20
10
MOVEMENT OF PLUNGER
150
130
110
90
DAKOTA CLEAR
VOLUME H2O TEXTURE AGE
#1-UNTREATED 2270 67% 90 (G)
#3-20 PPM BROMATE 2610 67% 96 (M+)
MINUTES of BAKING
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
#3-CANADA 95% PATENT-UNTREATED
OVEN BAKE-2190cc-85-(G)
CHART 6
VOLTS
130
110
90
TEMPERATURE
°F
210
190
170
VOLTAGE
MM
80
70
60
50
40
30
20
10
150
130
110
90
OVEN SPRING
PRESSURE
MINUTES of BAKING
1 HOUR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

required within the dough at the bottom of the pan to expand the dough at the rate of proofing. By subtracting the hydrostatic pressure from these values, an indication of the stress on the bubbles producing a strain in the dough can be obtained. When the dough is heated in the oven an abrupt rise in pressure immediately occurs, indicating the stress required to expand the dough at the approximately ten times faster rate of rise obtained when baking.

Also shown are the voltage, temperature rise, pressure variations, and oven spring of this unoxidized dough while being heated in the electric pan. The pressure slowly rises during the first few minutes of heating, then more rapidly to a peak, which often coincides with the zone of starch swelling, followed by an abrupt and large fall in pressure to below the hydrostatic level of the pressure of the dough, followed by a second rise during the alcohol distillation period to a second peak of approximately the same height as the first, and finally falling off as the heating approaches 212° F. with an abrupt fall to zero when the current is cut off. It is interesting to note that this abrupt fall upon cutting off the current indicates that the pressure in the chamber is in communication with the interior of the loaf and is evidence that these measurements indicate the pressure within the loaf.

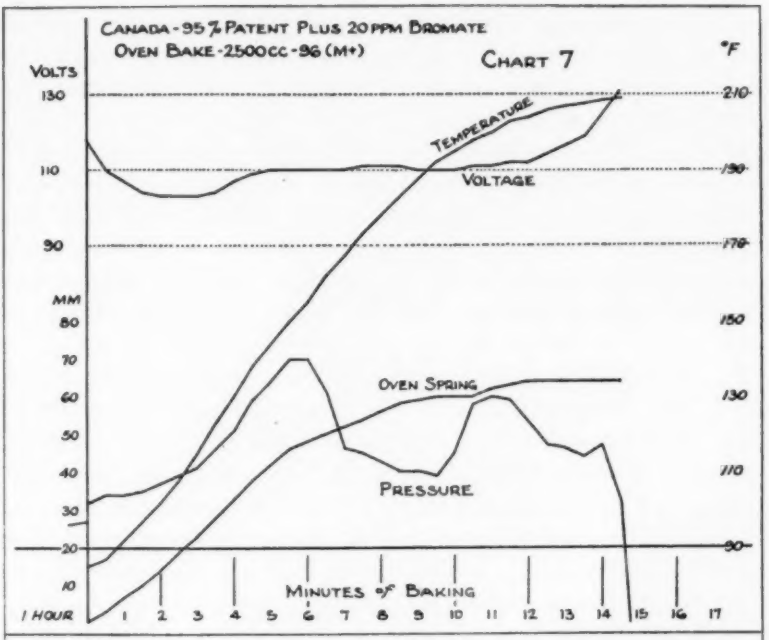
Crust bread baked from this same dough shows very little oven spring, a very green coarse texture, and all the characteristics of an untreated, unoxidized dough.

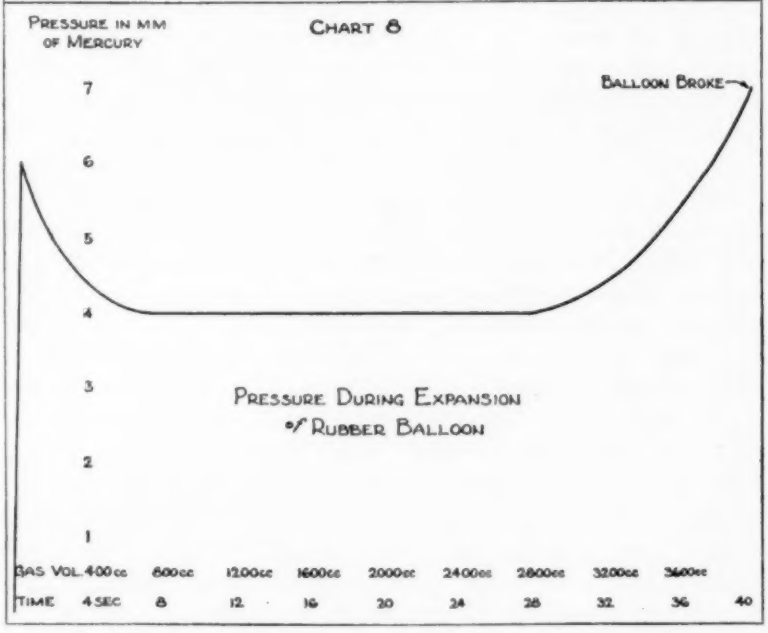
Chart 7 shows the same dough after being treated with bromate and is one that gives a large loaf of bread with good texture and maturity. It is to be noted here that the pressure during proofing is somewhat higher than with the untreated dough and that the pressure at the onset of baking rose at a steeper rate, reached a much higher level, and at the completion of the starch swelling showed only a partial drop in pressure. It also gives a subsequent rise upon the generation of alcohol pressure, which is followed by a decrease toward the end of the baking.

The outstanding characteristics of these pressure curves are:

1. The level at which they start.
2. The steepness of the ascending slope and height they reach and the length of time during which the pressure persists.
3. The temperature at which the pressure first falls.
4. The amount of the pressure fall after failure and its duration.
5. The amount of its return during alcohol distillation.

To aid in the interpretation of these curves Chart 8 shows the pressure in a thin elongated rubber balloon as it is blown up to the bursting point. It is to be noted that after the inflation is well started


CANADA - 95% PATENT PLUS 20 PPM BROMATE
OVEN BAKE - 2500 CC - 96 (M+)
CHART 7
°F
VOLTS
130
110
90
MM
80
70
60
50
40
30
20
10
210
190
170
150
130
110
90
TEMPERATURE
VOLTAGE
OVEN SPRING
PRESSURE
MINUTES OF BAKING
1 HOUR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17


PRESSURE IN MM OF MERCURY
CHART 8
BALLOON BROKE
7
6
5
4
3
2
1
PRESSURE DURING EXPANSION OF RUBBER BALLOON
GAS VOL. 400 cc 800 cc 1200 cc 1600 cc 2000 cc 2400 cc 2800 cc 3200 cc 3600 cc
TIME 4 SEC 8 12 16 20 24 28 32 36 40

the pressure remains constant, although the strain in the balloon is steadily becoming greater. Also as the breaking point is approached there is a marked rise in pressure until the tensile strength of the rubber is reached and the balloon bursts.[3] Calculations indicate that where the modulus is constant, a rubber balloon should expand with little change in pressure. When the pressure rises the modulus is increasing and the rubber approaches its elastic limit. One can interpret the pressure results obtained in our baking work in a similar manner; that zone where little pressure rise occurs suggests a constant modulus in the dough. Where the pressure rises the modulus may be considered as increasing and the cell walls approaching their elastic limit.

Our records show that where the best texture is obtained in bread a sharply ascending pressure curve is obtained as the dough is heated. Where little pressure rise occurs, good bread is not obtained. This zone, up to the peak, can be termed the "texture-creating zone" of the oven spring. If the pressure drops low after this peak, the corresponding bread exhibits a texture with non-uniform, round, enlarged bubbles, whereas if the pressure is well maintained during the heating and bridged over to the alcohol zone without much collapse, fine, elongated cells with matured texture are observed. This type of curve with steep ascent and no collapse is the most desired and exhibits the form for a good bread-making dough. Collapse is suggestive of puncture and possible coalescence of bubbles and a loss of texture.

A characteristic of our results where a drop of pressure occurs during or after starch swelling is that the oven spring shows no corresponding fall. In fact, in all cases the volume of the test dough is maintained and usually a slight increase in oven spring continues. One might find it difficult to explain how this can be. Obviously if the volume continues its rise there can be no complete loss of gas from the loaf during this fall in pressure. The explanation lies in the relation of bubble surface to gas volume. When two gas bubbles coalesce and form one, their combined surfaces form the new bubble and as the same amount of gas requires less surface in one bubble than in two the strain on the film must decrease, and this releases the stress and hence the pressure falls. It is believed that this is the phenomenon occurring when any marked drop in pressure occurs and hence a pressure drop indicates loss in texture by breaking and probable coalescence of bubbles but not necessarily excessive loss of gas from the loaf itself.

In these experiments the outer surface of the dough was prevented from controlling the pressure in the loaf by being sprayed with a dilute

[3] A circular balloon gives a similar curve but lacks the period of constancy.

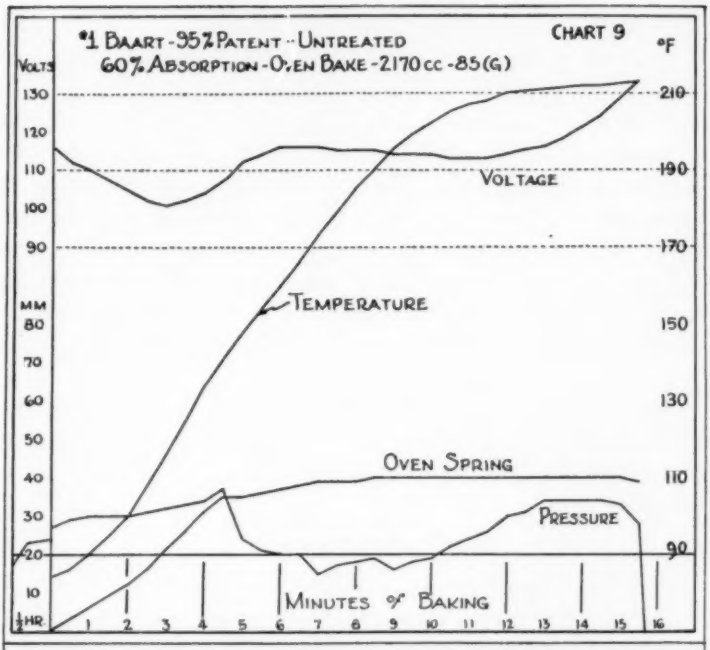


CHART 9
*1 BAART - 95% PATENT - UNTREATED
60% ABSORPTION - OVEN BAKE - 2170 CC - 85 (G)
VOLTS
°F
VOLTAGE
TEMPERATURE
OVEN SPRING
PRESSURE
MM
MINUTES of BAKING
½ HR

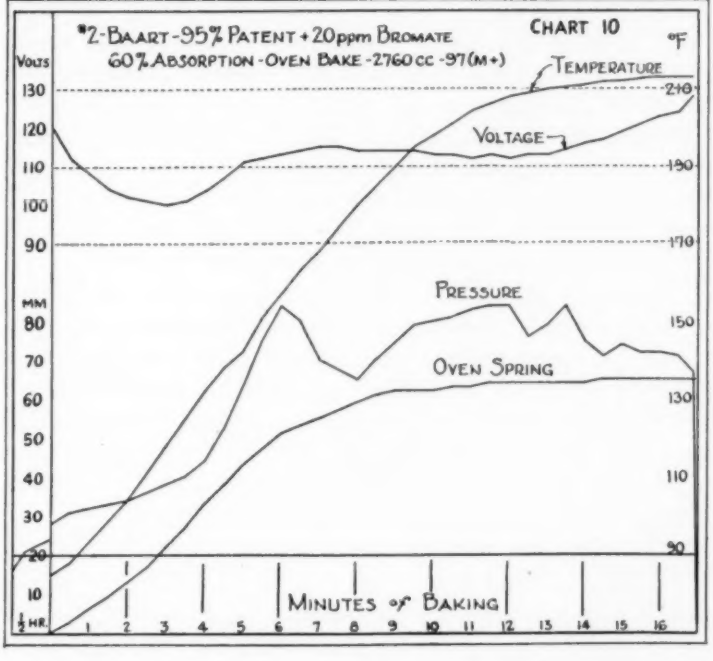


CHART 10
*2 - BAART - 95% PATENT + 20 ppm BROMATE
60% ABSORPTION - OVEN BAKE - 2760 CC - 97 (M+)
VOLTS
°F
TEMPERATURE
VOLTAGE
PRESSURE
OVEN SPRING
MM
MINUTES of BAKING
½ HR

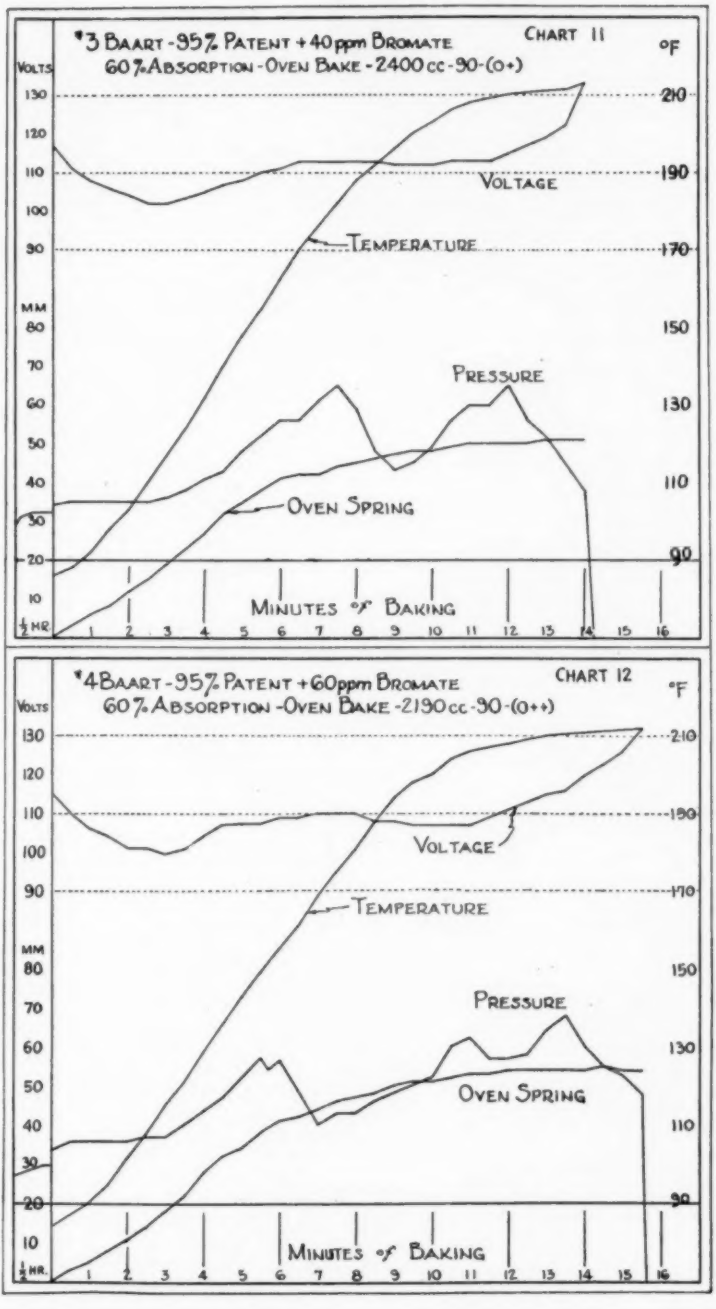
salt solution containing glycerin, and also by avoidance of water loss through use of a covering over the top of the pan.

We have been unable from the pressure curves alone to explain the phenomena that occur in overoxidized doughs, the characteristics of which may be tougher crumb, collapsed cell structure, occasional knotty whorls, a drawing in of the sides or the bottom of the loaf, and a parting of the crumb inside the loaf, usually under the crust. All of these phenomena indicate greater forces drawing the loaf inward. It may be that the voltage curves give the clew to this phenomenon and indicate a change in the dough properties with different oxidation. Gluten or starch may become firmer or more contractile in nature; hence a shrinkage occurs which gives its characteristics to overoxidized bread.

The work reported in Charts 9 to 12, showing the variations in dough properties during baking when treated with varying amounts of potassium bromate, has been repeated on different kinds of flour, with similar results.

## Discussion

These charts offer numerous suggestions as to the relation of physical properties and their influence upon dough while baking. It is apparent that all doughs show a voltage rise during approximately the same temperature range, which coincides with the swelling of starch. It is also apparent that the pressure in the dough shows a marked rise during the same period. The most rapid portion of the oven spring is also completed by the time this voltage rise has occurred. These generalizations can be seen in all of our work. It is apparent that the swelling of the starch by the taking up of water has reduced the conductivity and at the same time increased the force required to stretch the dough. The swelling of starch must result in the transfer of water from the gluten to the starch, resulting in a tightening of the gluten strands with a resulting decrease in their fluidity and hence an increase in their tensile strength. At the same time, the swelling of the starch must fix the location of the starch granules in the dough mass so that little further rearrangement of these granules may occur to enable the films to become thinner. There must hence be an increased demand on the elastic extension of the gluten for further oven spring, and starch rearrangement must be accomplished with increasing difficulty. When the pressure reaches that point where the tensile strength of the bubbles is exceeded and they puncture or break, with a resulting drop in pressure in the dough, the rate of oven spring decreases and more slowly exhibits itself thereafter. Hence, the earlier this drop in pressure occurs the lower the oven spring and the smaller


*3 BAART - 95% PATENT + 40 ppm BROMATE
CHART 11
60% ABSORPTION - OVEN BAKE - 2400 cc - 90 - (0+)
VOLTS
°F
VOLTAGE
TEMPERATURE
MM
PRESSURE
OVEN SPRING
MINUTES OF BAKING
½ HR
*4 BAART - 95% PATENT + 60 ppm BROMATE
CHART 12
60% ABSORPTION - OVEN BAKE - 2190 cc - 90 - (0++)
VOLTS
°F
VOLTAGE
TEMPERATURE
MM
PRESSURE
OVEN SPRING
MINUTES OF BAKING
½ HR

the volume. At the same time, if the breaking of the bubbles should occur early in the baking process, before the plastic properties of the dough have been largely lost by the swelling effect of the starch there must result greater coalescence of the bubbles from this puncturing of cells. Hence, the earlier the pressure drop occurs and the greater its magnitude, the coarser the texture one should expect. Our results indicate that this is largely true. The characteristics of the dough as shown by the dropping of the plunger (Chart 5) also indicate that the dough is at its maximum fluidity prior to and during the early stages of starch swelling. This is further evidence that the dough is in the optimum condition for coalescence of bubbles at this stage, so that if the cohesive properties of the bubbles are not strong enough to support the pressure, coalescence will occur.

Our work indicates that one of the effects of potassium bromate upon dough is to increase the pressure required to expand the dough, suggesting that the modulus of elasticity has been raised by the oxidation. The higher the degree of oxidation, the higher this initial pressure becomes, both at the end of the proof and at the beginning of baking. Pressure curves showing the sharpest rise and the most continuous maintenance of the pressure during all stages of baking without any failure or drop are found in those cases where the finest texture is obtained. Such doughs are rather rare, and ideal conditions must be obtained in order to get such a pressure result. However, when such a dough is obtained the resulting tinned bread is of very fine texture, large volume, and thin crust.

Halton and Scott Blair (1937) have pointed out that the quality of dough largely depends upon the relationship of the modulus of elasticity to the viscosity of the dough. In an effort to interpret our results in terms of their findings we have considered the following dough properties:

A. *Elastic Properties*
   1. The force required to stretch the dough film a unit distance or modulus of elasticity.
   2. The elastic extensibility of the dough.
   3. The increase in modulus of elasticity.
   4. The tensile strength of the dough.

B. *Plastic Properties*—The plastic flow of the dough includes
   1. The rearrangement of the structural position of the starch granules in the dough films.
   2. The flow of gluten itself.

It is obvious that the larger the number of bubbles a dough contains, the thinner the dough film becomes and the greater the amount of film surface present in the dough. It would appear that the thinness of a dough film should ultimately be limited by the diameter of the larger

starch granules in the dough. Preliminary microscopic observations on this point in our laboratory support this idea. If the diameter of the large starch granules determines the minimum film thickness that can be obtained, then the elastic properties come fully into play when the starch rearrangement has gone as far as it can in a particular dough. Starch rearrangement results from elastic strain which can thereby be relieved to some degree.

It is probable that many doughs are not sufficiently strong to carry the starch rearrangement to its ultimate limit before the film is broken. This must be the case in the ordinary unoxidized doughs from freshly milled flour. The pressure curves in such a dough during proofing and during the early stages of baking show little rise though they give the usual pressure jump on entering the oven. In such doughs large amounts of plastic and elastic extension must occur with a low modulus of elasticity. However, the tensile strength is low and is quickly reached in oven spring so that much rupture and coalescence occur. It would appear obvious that for doughs to exhibit their elastic phenomena, plastic flow must ultimately be subdued and become secondary. This suggests that primary plastic flow in doughs may be starch rearrangement, which by its motion interferes with the full elastic forces in the dough becoming aligned in the direction of the strains in the bubble surfaces. These elastic forces can only exhibit themselves to their maximum degree when starch rearrangement approaches its ultimate limit.

If a film of dough can no longer become thinner, then the pressure in a dough bubble must rise until the breaking point is reached. This is the phenomenon we have at the peak of the pressure curves. One might say the higher the pressure rises the greater the elastic modulus and the tensile strength. Given these properties, the higher the oven spring rises the greater must be the elastic extensibility and starch rearrangement rather than the plastic flow of the gluten. This would suggest that these are the physical properties which determine dough quality as evidenced by oven spring and fine texture. The greater their magnitude and duration, the better the texture and volume of the bread. However, should not plastic flow finally relieve the strain, there would be a shrinkage in a loaf with the final drop of pressure.

Stress would appear to be uniformly distributed throughout a dough mass, since any inequalities would be adjusted by the yielding of the films to maintain the balance of forces necessary in such an extended delicate foam structure.

During the period after the tensile strength has been exceeded (shown by drop of pressure on the curves) unequal bubble sizes will

be produced by rupture occurring at the weakest points in the films, thus producing larger cells with relief of stress and strain in the entire structure until generated or expanding gas renews the forces. It is of particular interest that the alcohol pressure usually does not greatly exceed the maximum carbon dioxide pressure. This top pressure is determined by the tensile strength and thus may be approximately the same in the two zones.

It can very well be that the alcohol pressure can produce further disruption of the cellular structure but it is very unlikely that cell formation or any coalescence will occur during this period because such alcohol pressures occur after the dough is set and substantially no longer extensible. It is very possible that elongated cell structure can be produced by alcohol pressure, though elongated cell structure is more likely to be produced by the motion of the dough during the oven spring in a dough which does not coalesce or lose its cellular structure but carries the pressure originally generated by carbon dioxide through to the alcohol zone and final coagulation.

In crust bread, because of unequal heating, the alcohol pressure in the exterior portions of the loaf must balance itself against the carbon-dioxide pressure in the middle. Any cell structure which has been disrupted by the carbon-dioxide pressure, in the outer layers, and hence unable to retain the subsequent alcohol pressure, will be packed against the crust by interior pressure in the loaf. The relation of this to crust thickness and texture gradation will be immediately seen.

## Summary

A method of testing doughs described by Baker has been investigated.

The crustless bread thus produced enables one to study the properties of dough independently of the influence of crust, while baking.

Dough is made the resistance unit between electrodes carrying alternating current. The voltage required to keep a constant wattage flowing, the temperature rise thus produced, the rate of oven spring, the fall of a bob through the dough, and the pressure generated in the dough during the baking, have been studied.

The rate of temperature rise in dough is retarded by carbon dioxide and alcohol being driven out of solution. These gases are the source of the pressure developed in baking dough.

The properties of the dough change most markedly while baking during the period of starch swelling, there being a marked rise in voltage, a rise in pressure within the dough, a marked change of the rate at which the weight falls through the dough, and a marked change in the rate of oven spring during this period.

The pressures generated within dough while baking are determined by the physical properties of the dough and indicate many of the characters of the bread which will be made from the dough.

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## COMPARATIVE DATA OBTAINED ON SOME 1938 HARD RED SPRING WHEAT VARIETIES BY THE USE OF FOUR BAKING FORMULAS

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The literature dealing with applications of various test baking methods or formulas to experimental flour testing is for the most part familiar to cereal chemists. Variations in mixing and fermentation times, as well as in the number and quantities of ingredients included in the baking formula, have been extensively investigated.

Blish (1934) pointed out that the basic procedure should be used essentially as a point of reference. Other supplementary methods could then be imposed, and the results obtained by the different procedures reported for comparative purposes.

Herman and Hart (1927) made a comparative study of different methods and formulas, and showed that powdered milk added to the basic formula decreased the loaf volume, crumb color, and grain, while it improved crust color. The absorption was not increased when milk powder was added. A shortening agent was incorporated with the basic formula in another experiment. Crumb color, grain, and crust color were improved by the shortening (a hydrostearoleine was used). Loaf volume was decreased when 3% of this shortening was employed.

Grewe (1928) found that dried skimmilk improved the baking quality of hard red spring wheat flour to a greater extent than hard winter wheat flour. In other cases the baking quality was impaired by milk unless flour improvers were also used. The color of the crumb was rendered more creamy and glossy by dry skimmilk, while break and shred were also improved. Skovholt and Bailey (1931) cited the growing importance of dried skimmilk in the baking industry, owing chiefly to the increased popular demand for greater nutritive value in the daily diet. These workers found that dried milk, especially if preheated, substantially improved the baking quality of a strong hard-wheat patent flour.

Aitken and Geddes (1934) concluded that the malt-phosphate-bromate formula with three-hour fermentation time yielded maximum differentiation between samples and gave the largest absolute loaf volumes when 10 composite samples of western Canadian hard red spring wheat flour were baked by various methods. Harris and Sanderson (1938) showed that the malt-phosphate-bromate formula gave better differentiation than the standard basic procedure between samples of North Dakota hard red spring wheat flours. A higher positive correlation was obtained between flour protein and loaf volume by the malt-phosphate-bromate method, while larger loaves were also produced, as compared with the standard basic procedure.

In view of the rather meager amount of experimental work which has been published regarding the effects of shortening and dried skimmilk as compared with the results obtained with the standard basic and malt-phosphate-bromate methods, it was thought desirable to obtain further information relating to the effect of formulas containing these ingredients upon North Dakota hard red spring wheats. Dried milk and shortening are quite commonly used in commercial baking, and the need of obtaining data on hard red spring wheat flour by the use of experimental formulas containing these ingredients has often been suggested to the author. Four methods or formulas were accordingly chosen for use in the following comparative studies.

The determination of the baking quality of a series of wheats which differ in genetic origin is always more difficult than in the instance of wheats which have a more or less common origin. The diversity of variety introduces quality differences into the picture. When dealing with plot samples the chemist is usually working with material at a fairly uniform protein level, and relationships between protein content and baking strength are more difficult to bring out than where a wide range in wheat protein is encountered. The latter situation usually arises when samples are drawn from a large area in which relatively few varieties are grown. Crop survey work would

fall into this classification. The investigational material used in this study would belong in the first group.

## Material and Methods

The wheats included in the present investigation consisted of varieties and selections which differed in genetic origin, but all belonged to the hard red spring wheat class. The samples were quite free from damage and no complicating factor was introduced because of injury from any cause. The samples, 26 in number, were cleaned, scoured, and tempered to a moisture content of 15% previous to milling into straight-grade flour on an Allis-Chalmers experimental mill. The protein content of the wheat was determined, as well as the flour protein. The flours were then baked by four methods—the standard basic; the malt-phosphate-bromate, which contained 0.3% of diastatic malt, 0.1% of ammonium di-hydrogen phosphate, and 0.001% $KBrO_3$; a milk-shortening formula which contained 4% dried skimmilk and 3% shortening in the form of highly refined lard; and the milk-shortening formula plus 0.001% $KBrO_3$ in addition to the basic ingredients. All formulas contained 5% sucrose. The mixing time used was two minutes in the Hobart-Swanson. Fermentation time and temperatures were as recommended in the standard basic method. The same absorption was used for each baking method.

## Discussion

The grades, test weight per bushel, crude wheat and flour protein, and flour ash are shown in Table I. It will be noticed that the grades and test weights were all relatively high, only one sample grading lower than 1 Dark Northern Spring, while the lowest test weight was 57.4. The wheat protein ranged from 13.3% to 17.0%, a difference of 3.7%, while the flour protein ranged from 12.5% to 16.2%, a difference also of 3.7%. These wheats showed a substantial variation in protein content and should, therefore, be expected to differ in baking quality because of these differences. Substantial differences in flour ash were also evident among the wheats.

The loaf volumes, texture, and color scores and corresponding means are presented in Table II, the data being grouped according to loaf volume, texture, and color, rather than method, to facilitate baking method comparisons. It is evident that the mean loaf volume increases in going from the standard basic through the milk-shortening and milk-shortening-bromate to the malt-phosphate-bromate method. The texture and color scores are not so easily differentiated according to baking methods used, and accordingly recourse must be had to statistical methods of handling the data to bring out these relation-

TABLE I

COMPARATIVE GRADES AND ANALYTICAL DATA OF SAMPLES ARRANGED IN ORDER OF INCREASING WHEAT PROTEIN CONTENT

| Lab. No. | Grade [1] | Test weight, lbs. per bushel | Crude protein [2] N × 5.7 | | Ash [2] |
|---|---|---|---|---|---|
| | | | Wheat | Flour | |
| | | | % | % | % |
| 38-9-38 | 2 DNS | 57.4 | 13.3 | 12.5 | 0.51 |
| 41 | 1 HDNS | 61.0 | 13.4 | 12.5 | 0.48 |
| 40 | 1 HDNS | 60.6 | 13.5 | 12.6 | 0.54 |
| 36 | 1 HDNS | 62.0 | 13.6 | 13.1 | 0.54 |
| 47 | 1 DNS | 59.5 | 13.7 | 12.6 | 0.45 |
| 39 | 1 HDNS | 60.7 | 13.8 | 12.7 | 0.54 |
| 49 | 1 HDNS | 61.3 | 13.8 | 13.0 | 0.65 |
| 28 | 1 DNS | 58.6 | 13.9 | 13.4 | 0.47 |
| 42 | 1 DNS | 59.5 | 13.9 | 12.5 | 0.50 |
| 45 | 1 HDNS | 60.8 | 14.1 | 13.1 | 0.54 |
| 31 | 1 DNS | 59.6 | 14.2 | 13.4 | 0.53 |
| 32 | 1 HDNS | 60.4 | 14.2 | 13.5 | 0.61 |
| 46 | 1 HDNS | 60.3 | 14.2 | 13.2 | 0.52 |
| 43 | 1 DNS | 59.3 | 14.3 | 13.0 | 0.53 |
| 48 | 1 HDNS | 62.1 | 14.3 | 13.1 | 0.50 |
| 30 | 1 HDNS | 60.6 | 14.4 | 13.6 | 0.52 |
| 34 | 1 HDNS | 60.8 | 14.4 | 13.5 | 0.39 |
| 50 | 1 HDNS | 61.5 | 14.4 | 13.3 | 0.51 |
| 37 | 1 HDNS | 62.0 | 14.5 | 12.6 | 0.58 |
| 44 | 1 HDNS | 61.2 | 14.5 | 14.0 | 0.52 |
| 52 | 1 HDNS | 62.5 | 14.5 | 13.5 | 0.68 |
| 29 | 1 HDNS | 62.0 | 14.6 | 13.4 | 0.54 |
| 35 | 1 HDNS | 60.6 | 14.8 | 13.5 | 0.37 |
| 51 | 1 HDNS | 62.0 | 14.8 | 13.5 | 0.41 |
| 33 | 1 HDNS | 60.4 | 15.4 | 14.5 | 0.41 |
| 53 | 1 HDNS | 60.0 | 17.0 | 16.2 | 0.42 |

[1] Unofficial.
[2] 13.5% moisture basis.

ships. The means, standard deviations, coefficient of variability, and simple correlation coefficients calculated from the analytical data are shown in Table III.

Examining first the values for the means and standard deviations it is seen that flour protein averages 1.0% below wheat protein, and is slightly more variable than the latter. The ash content has the highest relative variability of any of the values listed, due, to some extent at least, to the small quantity of ash contained in the flour as contrasted to the larger values of the other variables. The correlation constant shows a high relationship between wheat and flour protein. The constants between flour protein and loaf volume are all significant with the exception of the one between protein and milk-shortening-bromate loaf volume. The malt-phosphate-bromate value is small but significant. It will be noticed that the highest correlation exists between flour protein and basic loaf volume, which is contrary to the

## TABLE II

COMPARATIVE RESULTS OBTAINED BY THE FOUR BAKING METHODS ARRANGED IN ORDER OF INCREASING WHEAT PROTEIN CONTENT

| Lab. No. | Loaf volume | | | | Texture | | | | Color | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard basic | Milk-shortening | Milk-shortening-bromate | Malt-phosphate-bromate | Standard basic | Milk-shortening | Milk-shortening-bromate | Malt-phosphate-bromate | Standard basic | Milk-shortening | Milk-shortening-bromate | Malt-phosphate-bromate |
| | cc. | cc. | cc. | cc. | % | % | % | % | % | % | % | % |
| 38–9–38 | 477 | 598 | 653 | 650 | 94.0 | 94.5 | 93.5 | 94.0 | 93.0 | 94.0 | 94.0 | 93.0 |
| 41 | 495 | 544 | 649 | 720 | 94.0 | 93.5 | 93.0 | 90.0 | 94.0 | 94.0 | 93.5 | 95.0 |
| 40 | 490 | 564 | 601 | 697 | 94.5 | 93.5 | 94.0 | 91.0 | 93.0 | 93.0 | 94.0 | 94.0 |
| 36 | 541 | 567 | 611 | 666 | 94.0 | 94.5 | 94.0 | 93.0 | 93.5 | 94.0 | 94.5 | 93.5 |
| 47 | 491 | 580 | 619 | 710 | 93.0 | 93.5 | 95.0 | 92.5 | 93.0 | 92.0 | 94.0 | 93.0 |
| 39 | 467 | 573 | 631 | 715 | 93.5 | 93.5 | 93.5 | 93.0 | 93.0 | 93.0 | 93.5 | 93.0 |
| 49 | 520 | 548 | 609 | 674 | 93.5 | 94.0 | 94.0 | 92.0 | 92.0 | 93.0 | 93.0 | 93.0 |
| 28 | 595 | 618 | 688 | 762 | 93.0 | 93.5 | 92.0 | 92.0 | 93.0 | 93.0 | 94.0 | 93.0 |
| 42 | 490 | 594 | 594 | 620 | 93.5 | 93.5 | 94.5 | 92.0 | 93.0 | 93.5 | 94.0 | 92.0 |
| 45 | 489 | 568 | 616 | 693 | 93.5 | 93.5 | 93.5 | 90.0 | 93.5 | 93.5 | 94.0 | 94.0 |
| 31 | 522 | 548 | 617 | 732 | 93.5 | 94.0 | 92.0 | 92.0 | 93.0 | 94.0 | 93.5 | 93.5 |
| 32 | 506 | 544 | 602 | 713 | 94.0 | 94.5 | 93.0 | 92.0 | 93.0 | 94.5 | 94.0 | 93.5 |
| 46 | 548 | 568 | 589 | 630 | 93.0 | 94.0 | 94.0 | 90.0 | 94.0 | 94.0 | 94.0 | 95.0 |
| 43 | 488 | 596 | 640 | 644 | 93.5 | 93.0 | 92.0 | 91.5 | 92.0 | 93.5 | 94.0 | 93.0 |
| 48 | 572 | 621 | 686 | 738 | 94.0 | 93.5 | 92.0 | 90.0 | 94.0 | 94.0 | 93.0 | 95.0 |
| 30 | 532 | 578 | 632 | 715 | 92.0 | 93.5 | 92.5 | 91.5 | 92.0 | 93.0 | 93.5 | 93.0 |
| 34 | 600 | 601 | 641 | 707 | 92.0 | 93.5 | 91.5 | 90.5 | 93.0 | 93.5 | 93.0 | 92.5 |
| 50 | 560 | 610 | 717 | 707 | 93.5 | 94.0 | 92.5 | 91.0 | 94.0 | 94.0 | 93.0 | 92.0 |
| 37 | 546 | 589 | 660 | 683 | 93.0 | 94.5 | 92.5 | 93.5 | 94.0 | 94.0 | 94.0 | 93.5 |
| 44 | 582 | 616 | 644 | 718 | 93.5 | 93.5 | 92.5 | 92.0 | 94.5 | 94.0 | 94.0 | 94.0 |
| 52 | 570 | 612 | 662 | 701 | 94.0 | 93.0 | 91.0 | 91.0 | 94.0 | 95.0 | 93.5 | 94.5 |
| 29 | 660 | 626 | 761 | 784 | 92.5 | 94.0 | 92.0 | 92.0 | 94.0 | 94.0 | 94.5 | 93.0 |
| 35 | 535 | 610 | 672 | 689 | 93.5 | 93.0 | 91.5 | 91.0 | 94.0 | 94.0 | 94.0 | 94.0 |
| 51 | 540 | 622 | 653 | 699 | 93.0 | 94.5 | 92.5 | 92.0 | 94.0 | 95.0 | 96.0 | 94.5 |
| 33 | 535 | 568 | 591 | 706 | 93.0 | 93.5 | 92.5 | 92.5 | 93.5 | 94.0 | 93.5 | 93.0 |
| 53 | 693 | 753 | 737 | 764 | 92.0 | 91.5 | 90.0 | 91.0 | 94.0 | 95.0 | 93.0 | 94.0 |
| Means | 540.15 | 592.92 | 645.19 | 701.42 | 92.33 | 93.65 | 92.75 | 91.65 | 93.38 | 93.75 | 93.69 | 93.50 |

## TABLE III

TABLE OF STATISTICAL CONSTANTS
MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY

| | Means | Standard deviations | Coefficients of variability |
|---|---|---|---|
| Wheat protein % | 14.30 | 0.719 | 5.03 |
| Flour protein % | 13.30 | 0.752 | 5.65 |
| Flour ash % | 0.502 | 0.114 | 22.71 |

Simple Correlation Coefficients

| Variables correlated | | | |
|---|---|---|---|
| *X* | *Y* | *rxy* | *p* [1] |
| Flour protein | Wheat protein | +.9148 | <.0001 |
| Flour protein | Loaf volume (standard basic) | +.7158 | <.0001 |
| Flour protein | Loaf volume (milk-shortening) | +.6869 | .0002 |
| Flour protein | Loaf volume (milk-shortening-bromate) | +.3650 | .0672 |
| Flour protein | Loaf volume (malt-phosphate-bromate) | +.4635 | .0172 |

[1] *p* = probability of the observed correlation coefficient arising from uncorrelated material through errors of random sampling.

results usually obtained, as the malt-phosphate-bromate method commonly gives the highest correlation between these variables. There is a possibility in the present instance that the diversity of genetic origin and variety has introduced a complicating factor into the situation and has altered the degree of relationship between flour protein and loaf volume as shown by the different methods.

In order to evaluate the significance of the differences in the results between baking methods, as well as between wheat varieties, the analysis of variance was applied to the data. Two criteria of classification were used—grouping according to baking method and according to wheat variety. The mean square for interaction can be used to test the variety means only if an assumption is made that there is a random selection of methods. The inclusion of the color and texture scores in the analysis may be somewhat debatable owing to the slight variability evident among the percentages and the fact that they are subjective measurements. The results obtained are set forth in Table IV, which shows the source of variation with corresponding degrees of freedom, sums of squares, mean squares, F values, and the 5% point.

TABLE IV

ANALYSIS OF THE DATA

| Source of variation | Degrees of freedom | Sum of squares | | | Mean square | | | F values | | | 5% Point |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Loaf volume | Texture | Color | Loaf volume | Texture | Color | Loaf volume | Texture | Color | |
| Total | 103 | 579,746 | 145.04 | 50.06 | — | — | — | — | — | — | — |
| Between methods | 3 | 373,696 | 60.17 | 2.24 | 124,565.33 | 20.0567 | 0.7647 | 166.83 | 33.37 | 2.18 | 2.73 |
| Between varieties | 25 | 150,051 | 39.79 | 22.12 | 6,002.04 | 1.5016 | 0.8848 | 8.04 | 2.65 | 2.58 | 1.66 |
| Interaction (Method X Varieties) | 75 | 55,999 | 45.08 | 25.70 | 746.65 | 0.6011 | 0.3427 | — | — | — | — |

Variations in mean loaf volumes were significant as between baking methods and also between varieties. The same tendency appeared with reference to variations in texture. With respect to color, variations between methods were not significant, but were significant between varieties.

Break, shred, and the general appearance of the loaves were substantially enhanced by the addition of dry skimmilk and shortening.

## Summary and Conclusions

A series of 26 samples of hard red spring wheats differing in genetic origin were milled into straight flours on an Allis-Chalmers experimental mill. The wheats were graded and analyzed for crude protein. The test weights and grades of these samples were relatively high.

The resultant flours were analyzed for crude protein and ash, and were baked by four procedures—the standard basic method with 5% sucrose; a milk-shortening formula, including 4% dry skimmilk and 3% shortening; a milk-shortening-bromate formula, which included the milk-shortening formula plus 0.001% $KBrO_3$; and the malt-phosphate-bromate formula. The three latter formulas were all superimposed upon the standard basic.

The results obtained from the analytical work showed a range of 3.7% in both wheat and flour protein between the highest and lowest protein samples. The ash was quite variable in the flours of this series. A very significant difference in mean loaf volume among the four baking methods was revealed by the analysis of variance. These mean loaf volumes increased in the order in which they are given. The mean texture scores also differed significantly between the methods, while crumb color showed no significant differences.

If a random selection of methods were assumed it was evident that there were significant differences among variety means in respect to loaf volume and color and texture scores, thus demonstrating significant variability in baking strength among the hard red spring wheat varieties.

Correlation coefficients for flour protein and loaf volume for the four baking methods were +.7158, +.6869, +.3650, and +.4635, respectively. All the correlations except the third one were significant. These values would doubtless have been definitely larger if a wider range of protein content and baking strength had been present in the series of wheats studied.

The data obtained in the present study demonstrated the differences in loaf volume, and to a lesser degree in texture score, yielded by different formulas used in baking flours milled from hard red spring wheats which differ in genetic origin. Current opinions regarding differences in the baking strengths of the individual wheats investigated were also substantiated by this work.

**Acknowledgments**

The author is indebted to T. Sanderson, who conducted the experimental milling tests, and to Muriel Johnson, who performed the statistical work connected with this study. Acknowledgment is also made of valuable advice regarding the statistical analysis of the data contributed by Gertrude M. Cox, Statistical Laboratory, Iowa State College.

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# PRESIDENTIAL MESSAGE

W. F. GEDDES

University of Minnesota
Saint Paul, Minnesota

(Read at the Annual Meeting, May 1939)

The history of our Association records that on the eighth day of May, 1915, eleven mill chemists in the Southwest met in Kansas City, Missouri, at the call of the late Mr. H. E. Weaver, to form an organization for "the advancement of the science as applied to cereal analysis." It is particularly fitting that we should hold this, our twenty-fifth annual meeting, in the city in which our Association was formed and thereby acknowledge the debt we owe to our charter members, all cereal chemists of the Southwest, in establishing our organization on a firm scientific foundation.

It seems only appropriate that we should pause briefly and take stock of some of the developments of the past twenty-five years. A retrospect alone affords a proper comprehension of our present status and leads us to the conviction that we live in a state of continuous transition, that our ideas of today are merely the precursors of others and that even they cannot for any length of time satisfy the requirements of science. Man aims to achieve, the human spirit strives to surmount difficulties; it glories in creative power, and the illustrious achievements that have been recorded in the application of chemistry to industry during the past quarter of a century have made a striking appeal to the human mind.

In primary and secondary industry, it has meant the creation of increased wealth, increased employment and enhancement of the general welfare of the people. For these reasons, science is considered today one of the most effective agencies in influencing the attitudes of thoughtful men.

Progress has been so rapid that it is difficult, indeed, for us to appreciate the conditions that prevailed in our own specialized field little more than twenty-five years ago. Prior to 1915, our history records that in mills the character of the mill mix was governed by the manager's "wheat sense," the price policy, and the weather. Flour bleaching was limited to the use of nitrogen peroxide, wheat was chewed to determine its quality, washed glutens were standard determinations among millers and flour buyers, and the miller's wife was the "test-baker" whose verdict decided the quality of the flour. Cereal chemistry was just beginning to emerge as a distinct branch of the young and flourishing science of biochemistry, and a few of the more progressive

millers were coming to realize that laboratory control was essential. With the advent of the laboratory much confusion in the trade resulted, since the methods of conducting and reporting analyses varied and secrecy was the order of the day.

Thus the Association had a simple and natural origin, and therein we find its primary aim, the establishment, by means of research and discussion, of standard methods of procedure in the analysis of cereal products. From this modest beginning as regards both membership and activities we have experienced a healthy growth. At the present time our total membership stands at 608, 69 of whom reside in foreign countries, and the majority of the leaders in cereal chemistry throughout the world, whether in university work, research, or industry, are now banded together in this body to serve the well-being of matters relating to applications of their specialized knowledge. One of the most noteworthy facts is the manner whereby our Association has unified cereal chemistry in this country from coast to coast. This Association has brought together the cereal chemists from many laboratories, and we have all grown in breadth of vision and in increased usefulness in our profession because of the contacts and friendships which have develped in this Association. Furthermore, we have attained a professional status in the cereal industry which would have been impossible to secure had we all insisted on following our own individual pathways. A highway of cereal chemistry now exists where 25 years ago there were only overgrown footpaths through a wilderness.

Our objectives have been expanded to include not only the study and development of standard methods but also the advancement of scientific and technical research in the cereal and associated industries, promotion of the spirit of scientific cooperation, "the encouragement of more general recognition of the importance of the chemist and biologist in the cereal industries and the maintenance of high professional standards as conditions for membership."

The extent to which these objectives have been achieved is to be detailed elsewhere at this meeting. The chemistry of flour milling technology has advanced rapidly from the organic chemical to the biochemical and physical viewpoints and techniques, and today the industrial laboratory has been placed on a plane where it takes part in original discoveries as well as in their applications. The fertility of research and the wealth of literature has been so great that it would have been virtually impossible for many cereal chemists, who are without extensive library facilities, to keep in touch with recent advances without the existence of our journal, *Cereal Chemistry*, which is attracting an ever increasing number of papers on fundamental and technological researches in this field.

The success which has been attained by our various technical committees illustrates the value of the collaborative method of attack; progress in technological fields requires the coordinated effort of many individuals, each fitting his contribution into its place in the puzzle.

An accounting of the activities of the current Association year will be given in the report of the Executive Committee. It has been a successful one scientifically and financially. The policy of effecting a greater continuity in the membership of our technical committees has been developed further; this has only been made possible through the willingness of several members to carry on their tasks, and to these we are deeply grateful. This year a new committee—the Committee on Cooperative Research—was appointed to cement more closely our relations with technical organizations in the milling and baking trades. This committee has cooperated with the American Society of Bakery Engineers in undertaking an extensive study of the effect of the mineral constituents of water on dough fermentation, the results of which were presented at the annual meeting of the Bakery Engineers held in Chicago last March.

The real work of this Association is carried out by the local sections, the various committees, the other officers, and the staff of *Cereal Chemistry*. A spirit of friendliness and cooperation has prevailed at all times, and I am deeply grateful to all for this attitude which has made the duties of the president so inarduous and pleasant.

At the business session you will be asked to vote on certain proposed amendments to the constitution which have crystallized as the result of very careful consideration extending over the past three years. It is not proposed here to discuss those amendments designed to facilitate and regularize our business activities, but it seems desirable that I should comment briefly on the proposal to strengthen our membership requirements. This is a matter upon which I fully realize there is room for difference of opinion. On the one hand we may take the attitude that this Association can perform the greatest service to society by maintaining our present membership requirements which admit those of rather limited formal chemical training or practical experience as such individuals would be particularly benefited through membership. On the other hand, one of the avowed purposes of this Association is the maintenance of high professional standards as a condition of membership and many feel that our existing requirements are not sufficiently rigid to ensure our continued recognition as a strictly professional organization.

The lawyer and the doctor, by a sufficiently long, arduous, and specialized course of learning, become sufficiently acquainted with

their specialties to be admitted by the State to practice. The general public knows the purpose of these professions and recognizes that those practising them are reasonably competent to do so. The public cannot for itself judge the value of the chemist, for it knows but little of his work or of the standards which should stamp him as a sound member of his profession.

It is worthy of note that steps have been taken by the American Chemical Society to prepare an accredited list of colleges offering specialization in chemistry, the curricula of which are regarded as of a sufficiently high standard to designate their graduates as adequately trained chemists. The News Edition of *Industrial and Engineering Chemistry* for April 20th, carries an interesting case history of a decision of the United States Supreme Court in which the professional status of the chemist is legally established. The trend of the times in all fields of science is towards more rigid requirements, and we would be well advised to take cognizance of these developments.

Until such time, if ever, as it should seem feasible and desirable to a large majority of the chemists of this country to exert the same sort of legal restriction for the practice of our profession as is now clearly desirable for law and medicine, it is my humble opinion that this Association can best carry out its aims and objects by insisting on sufficiently high standards of admission as to stamp its members as sound and reliable chemists who can safely be employed and relied upon for any work within their special fields. We have maintained high standards by bringing within our membership the majority of the outstanding chemists in the field, and it appears that hereafter we should set such standards of admission as will ensure that membership be not too easy to attain and be, therefore, valuable of attainment by the younger chemist. What is gained too easily is little appreciated. Moreover, chemistry is more and more assuming cultural and social values and in the future most educated persons may be expected to possess, as a kind of common knowledge, much of that which is now viewed as highly specialized information.

I look forward to the day when membership in the American Association of Cereal Chemists will be an almost necessary qualification for the consideration of an individual for the post of director of a cereal laboratory or for the more important technical positions in such laboratories.

To be a chemist requires training, and while a degree in chemistry is the best indication that this has been successfully accomplished, it would be a narrow view to take that all standards of admission should be referred to a purely university conception of education. The

amendments being brought forward by the Membership Requirements Committee provide that four years of practical experience involving varied chemical and technological determinations will be recognized in lieu of two years of formal training. It is also proposed to establish a Membership Application Committee to pass upon all applications, thereby relieving the Treasurer and the Executive Committee of the duty of reviewing applications. In the event the Association agrees that this is a desirable method of dealing with applications, I would recommend that the personnel of the committee should be so selected in successive years as to ensure that continuity of opinion which is essential for the creation of a reasonable permanence of standard.

It is the prerogative of the president to make suggestions as to possible future activities. One of our aims as expressed in the constitution is the encouragement of "a more general recognition of the chemist and biologist as essential factors in the development of the cereal industries." In this connection our Publicity and Inter-relations Committees have done excellent work, but it seems to me that there is still another avenue of approach to the public which we can legitimately explore. Can we not establish annual public lectures, given under the auspices of our local sections at the various centers, which would be stimulating and informative alike to the general public and to those connected with the cereal industries? These might well deal not only with the general advances which are being made in cereal technology, but also with the part that our own members have played. In fostering such an activity, however, we must bear in mind that the essence of our success will depend less on publicity for the organization than on what it can do in quiet accomplishment.

Insofar as we recognize our duties and capacities, so others will evaluate them. Of the past and present we can speak well. Men of unusual energy, vision, good will, and creative capacity have gone before and are among us. For the future I have no fear if, in our individual capacities, we have some care for the greater structure of which we form a part. We hold a trust which, if developed and nurtured with broad understanding, will serve a valuable and essential need and assure the continued success of this Association.

We are now assembled for our twenty-fifth annual meeting, and a perusal of the program indicates that those responsible for the numerous arrangements have worked diligently and efficiently to provide an instructive and entertaining week. It is my pleasure at this time to extend felicitations to our sister organization, the American Society of Brewing Chemists, which is meeting concurrently with us and with which a joint technical session has been arranged on Tuesday morning.

As the speaking voice of the American Association of Cereal Chemists, I desire to express to their members our keen interest in their work, to assure them of our cooperation, and to extend a hearty invitation to participate with us in all the scheduled events of the week.

In closing I cannot more aptly express the relation of our Association to the cereal industries than by quoting from an address by Mr. James Ford Bell, Chairman, Board of Directors, General Mills, Inc., before the Northwest Section, on March 31st last.

"Scientific research is industry's secret of perpetual youth. Without the constant infusion of new ideas from the laboratory and the testing plant, industry grows old, and progressively loses its vitality, until it is finally laid away as a useless relic of the past. It is industry's business to make and sell, but it is the business of science to teach industry what to make, and how to make its products better. It is to the scientists that the flour and cereal milling industry looks, and must look, for its chief guidance in the future if it is to hold and strengthen its position as one of the great servants of mankind."

# MINUTES OF THE TWENTY-FIFTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

The President Hotel, Kansas City, Missouri

May 22 to 26, 1939

J. M. DOTY, *Secretary*

The largest group ever in attendance at a meeting of the American Association of Cereal Chemists gathered for the opening of the Silver Anniversary Meeting at the President Hotel in Kansas City, Missouri. President W. F. Geddes called the meeting to order at 9:40 a.m. on Monday, May 22, 1939. The invocation was given by the Rev. David H. Owen.

Dr. Geddes then asked all to stand for one moment of silence in remembrance of Dr. A. D. Barbour, who had died during the year.

The President introduced the Hon. Bryce B. Smith, Mayor of Kansas City, who welcomed all members and friends to the city.

The Secretary was called on to read letters and telegrams from the following: C. W. Partridge, Secretary of the Association of Operative Millers, who extended their best wishes; L. D. Whiting, a past president who could not attend this year's meeting but who wanted to wish us a most successful convention; and Swen Young, Chairman of the Toronto Section. Kent Jones also sent regrets that he could not meet with us.

Dr. Geddes then read his Presidential Message, printed in this issue of *Cereal Chemistry*.

Perie Rumold, Chairman of the Local Arrangements Committee, made announcements about the plans for the picnic and golf tournament to be held that afternoon.

Dr. Geddes introduced R. J. Clark, Past President, who in turn introduced all past presidents attending the meeting. They were C. J. Patterson, R. W. Mitchell, S. J. Lawellin, M. J. Blish, M. A. Gray, C. G. Harrel, R. K. Durham, R. C. Sherwood, Mary M. Brooke, Washington Platt, and C. H. Bailey. These people were called to the speaker's platform while Mr. Clark gave his address on the subject, "Achievements."

Next Dr. Geddes introduced Dr. E. R. Weidlein of the Mellon Institute, who talked on "Advance through Scientific Research." A copy of Dr. Weidlein's talk will be found in the Proceedings of the Twenty-Fifth Annual Meeting of the American Association of Cereal Chemists.

Dr. Geddes then introduced Dr. John H. Parker, who presented a paper entitled "The Cereal Chemist and Wheat Improvement."

Our guest speaker, William Hauck, President of the American Society of Bakery Engineers, was then introduced. He presented a paper entitled "Appreciation of the Contribution of Cereal Chemistry to the Baking Industry."

Dr. Geddes recessed the morning meeting at 12:30 p.m.

Monday afternoon was taken up with the picnic at the Hillcrest Country Club. Included in the afternoon's entertainment were the golf and pistol tournaments, bingo games, shooting exhibitions, awarding of prizes, etc.

## TUESDAY, MAY 23

The Tuesday morning session was a joint meeting with the American Society of Brewing Chemists. The meeting was called to order by Dr. Geddes, who welcomed the brewing chemists and expressed his appreciation of their excellent cooperation. He then introduced G. S. Bratton, President of the Society of Brewing Chemists, who thanked the American Association of Cereal Chemists for the opportunity of meeting with them in joint session.

Dr. Geddes introduced Phillip P. Gray, member of the Society of Brewing Chemists, who presided over this session.

Dr. Gray introduced the rest of the speakers on this program.

Paper—"Time Lapse Motion Photo-Micrographic Studies of Yeast Cells," by Charles N. Frey, George W. Kirby, William Schanzenbach, and Freeman Swift. Read by George W. Kirby.

Paper—"Barley and Malt Studies. VI. Experimental Malting of Barleys Grown in 1938," by J. G. Dickson, A. D. Dickson, H. L. Shands, and B. A. Burkhart. Read by A. D. Dickson.

Paper—"A Modification of the Wohlgemuth Method for the Determination of Alpha-Amylase and Comparison with a Viscosity Method," by Lawrence E. Ehrnst, George J. Yakish, William Olson. Read by Lawrence E. Ehrnst.

Paper—"A Standardized Wohlgemuth Procedure for Alpha-Amylase Activity," by R. M. Sandstedt, Eric Kneen, and M. J. Blish. Read by R. M. Sandstedt.

Paper—"Electrometric Determination of Diastatic Power of Malts," by B. A. Burkhart.

Paper—"Heat Inactivation of Enzymes During Mashing," by Kurt Becker, Ralph G. Swanson, and Thomas P. Kruzic. Read by Kurt Becker.

Paper—"Polariscopic Determination of Proteolytic Activity," by Quick Landis.

Paper—"Protein Modification of 1939 Mid-Western Malts," by Stephen Laufer.

Paper—"Laboratory Malting. III. Steeping Equipment and Method," by J. A. Anderson and W. O. S. Meredith. Read by W. O. S. Meredith.

Paper—"A Chemical Method for Determining Pasteurization Effects," by Robert I. Tenney, Nicholas S. Yanick, and Fred A. Wilcox. Read by Robert I. Tenney.

Paper—"The Role of Cereal Adjuncts in the Brewing Process," by Louis Ehrenfeld.

Paper—"Practical Research in the Brewery," by George B. Sippel.

Paper—"A Review of Modern Methods in the European Brewery Laboratory," by Bertel Krause. Dr. Krause accompanied his talk with very interesting pictures taken in some of the European laboratories.

On account of the length of the morning session, Dr. Krause's second paper was held over for the afternoon session. Dr. Gray turned the meeting over to Dr. Geddes, who recessed the meeting until 2:00 p.m. at 12:55.

After calling the afternoon meeting to order at 2:05 p.m. Dr. Geddes turned the proceedings over to C. H. Bailey, who presided at this session. Dr. Bailey read the paper which was to have been given by G. W. Scott Blair, who was unable to attend because of the sudden illness of his wife.

Paper—"Psychorheology in the Bread Making Industry," by G. W. Scott Blair. Read by C. H. Bailey.

Paper—"The Value of the Normal Farinogram for Predicting the Baking Strength of Western Canadian Wheats," by W. F. Geddes, T. R. Aitken, and M. H. Fisher. Read by W. F. Geddes.

Paper—"Quality Tests on Hard Winter Wheat," by R. K. Larmour, E. B. Working, and C. W. Ofelt. Read by R. K. Larmour.

Paper—"Further Observations on Dough Structure—a New Method of Standardization of Dough Properties," by C. W. Brabender.

Paper—"Plasticity of Doughs," by O. E. Stamberg and C. H. Bailey. Read by O. E. Stamberg. This paper finished the Symposium on Physical Methods Applied to Dough Properties and Wheat Quality Evaluation.

The paper scheduled for the morning session by Dr. Krause was introduced and presented at this time.

Paper—"Diastase in Barley and Wheat and Its Liberation," by Bertel Krause.

Paper—"The Proteinase Content of Wheat Flour," by W. S. Hale.

Paper—"A Review of the 1938 Literature Pertaining to the Field of Cereal Chemistry," by W. S. Hale.

Dr. Bailey recessed the Tuesday session at 5:25 p.m.

## WEDNESDAY, MAY 24

President Geddes called the meeting to order at 9:15 a.m. He then called on the Secretary to read the minutes of the last meeting. The Secretary moved that the reading of the minutes be waived and that the minutes as printed in the July, 1938, issue of *Cereal Chemistry* be approved without reading. Seconded by G. F. Garnatz. Carried.

The Chairman called for a report from the Treasurer. Dr. Skovholt moved that the treasurer's report as printed in the March, 1939, issue of *Cereal Chemistry* be accepted. Seconded by R. J. Clark. Carried. Dr. Skovholt again pointed out the need for action in preparing to revise and reprint "Cereal Laboratory Methods."

The Auditing Committee was called on to make a report. That report was read by the Secretary, who moved its adoption. Seconded by C. A. Glabau. Carried.

President Geddes called for a report from the Editor-in-Chief of *Cereal Chemistry*. M. J. Blish moved the adoption of his report. Seconded by Avery Dunn. Carried.

The report of the Managing Editor was read by R. M. Sandstedt, who moved the adoption of his report. Seconded by R. H. Harris. Carried.

D. A. MacTavish made a report on the work of the Membership Committee and moved the adoption of this report. Seconded by Paul Logue. Carried.

C. A. Glabau was called on to report the work of the Committee on Employment. Mr. Glabau moved this report be adopted. Seconded by Lawrence Zeleny. Carried.

R. W. Mitchell read a report from the Committee on the Osborne Medal Award. Mr. Mitchell moved the adoption of this report. Seconded by J. T. Flohil. Carried.

A report from the Inter-Relations Committee was called for but since no member of this committee was present, the report was postponed.

R. J. Clark read and moved the adoption of the report of the History Committee. Seconded by W. Platt. Carried.

President Geddes called on Mary Brooke, who read the report of the Committee on Cooperative Research and moved its adoption. Seconded by G. E. Findley. Carried.

Paul Logue, Chairman, made a report for the Investment Committee and moved its adoption. Seconded by H. D. Liggitt, Jr. Carried.

Victor E. Marx read and moved the adoption of the report of the Publicity Committee. Seconded by J. A. Dunn. Carried.

In the absence of G. N. Bruce, Secretary Doty read the report of the Traffic Committee and moved adoption of the report. Seconded by Paul Logue. Carried.

Dr. Geddes called on R. C. Sherwood, Chairman, to report on the work of the Committee on Requirements for Membership. Dr. Sherwood read the recommendations and moved their adoption. He explained that the adoption of this report in no way bound the members to make the constitutional changes recommended but merely approved the work of the committee. Seconded by J. A. Shellenberger. Carried.

The Vice-President, G. F. Garnatz, Chairman of the Executive Committee, made and moved the adoption of the report of the work of that committee. Seconded by C. N. Frey. Carried.

C. G. Harrel reported for the Inter-Relations Committee and moved adoption of his report. Seconded by W. L. Heald. Carried.

Dr. Bailey moved that the amendments to the Constitution be made section by section rather than as a whole. Seconded by H. D. Liggitt. Carried.

Dr. Bailey moved that Article III, Section 1, be changed to read, "The Membership of this Association shall be divided into three classes, (1) active, (2) honorary, and (3) sustaining." Seconded by R. W. Mitchell. Carried.

Dr. Bailey moved that Article III, Section 2, be changed to read, "Eligibility for active membership in this Association (subsequent to May 24, 1939) shall be restricted to

"(*a*) those persons having the Bachelor's degree with a major in science from a college, university, or technical school of recognized standing, or having at least four years of collegiate training with a major in science in such an educational institution.

"(*b*) those persons presenting evidence that they have had at least two years of training in chemistry, plus four years of practical experience in a chemical laboratory involving varied chemical and technological determinations." Seconded by H. K. Parker after considerable discussion. Carried.

Dr. Bailey moved that Article III, Section 3, be changed to read, "Application for active membership shall be made in writing, endorsed by at least one active member in good standing, accompanied by the proper fee and directed to the Treasurer, who in turn shall refer the application to the Membership Application Committee, its decision to be final, and upon report to the Treasurer to be transmitted by him to the candidate." Dr. Bailey then pointed out that at the time the above change was voted on the members should also vote on Article IV, Section 8, which should be changed to read, "Membership Application Committee. The President shall appoint a Membership Application Committee, consisting of three active members, two of whom shall be past national officers, the duties of said Committee to be the examination of applications for membership, with full authority to approve or disapprove, in accordance with the provisions of Article III, all applications submitted to it by the

Treasurer. Upon reaching a decision the Committee shall notify the Treasurer, who shall inform the candidate of the disposition of his application." Both motions were seconded by C. N. Frey. Carried.

Dr. Bailey moved that Article III, Section 4, be changed to read, "Honorary members may be elected by a three-fourths majority vote of the active members present at any general meeting, the candidate to be first proposed by one or more active members to the Executive Committee, who in turn shall report on the qualifications of the candidate to the general meeting." Seconded by W. Platt. Carried.

Dr. Bailey moved that Article III, Section 5, be changed to read, "Corporations, institutions or individuals who are interested in or concerned with the use of cereals or cereal products may become sustaining members upon application to the Treasurer, in accordance with Section 3, Article III." Seconded by W. M. Cathcart. Carried.

Dr. Bailey moved that Article V, Section 4, be changed to read, "Sustaining members. The dues of sustaining members shall be ten dollars per annum, from January first to December thirty-first. Said dues are payable in advance, and shall be allotted to the publication fund." Seconded by F. C. Hildebrand. Carried.

Dr. Bailey moved that Article VI, Section 5, be changed to read, "Privileges of Honorary and Sustaining members.

"(*a*) Honorary members, sustaining members (and/or their representatives) shall have the privilege of attending all general meetings and in addition the privilege of the floor, but shall have no vote.

"(*b*) Honorary and sustaining members shall be entitled to receive the regular publications of the Association and may have the privileges of membership in a local section." Seconded by P. Logue. Carried.

Mr. Garnatz moved that Article IV, Section 1, be changed to read, "The elective officers of this Association shall be six in number: namely, President, Vice-President, Secretary, Treasurer, Editor-in-Chief, and Managing Editor of *Cereal Chemistry*. All officers except the Treasurer shall assume the duties of their offices at the end of the Annual Convention. The Treasurer's term shall be for the calender year following his election." Seconded by J. A. Dunn. Carried.

Mr. Garnatz moved that Article IV, Section 4 (*d*), be changed to read, "The Treasurer shall collect all fees and moneys due the Association, and pay all bills by check, and shall record all such receipts and expenditures. Bills shall not be paid except with the approval of the Vice-President. The Treasurer shall also keep the membership roster of the Association. Routine duties involving the collection of dues and keeping of membership records may be delegated by the Treasurer to an Assistant, at the discretion of the Executive Committee." Seconded by W. Platt. Carried.

Quick Landis moved to delete the word *Treasurer* after the word *Assistant* in the above change. Seconded by M. J. Blish. Carried. Therefore the above change stands.

Mr. Garnatz moved that Article IV, Section 5, be changed to read, "(*d*) The Executive Committee may, at their discretion, employ an Assistant for the transaction of such detailed business and financial affairs of the Association as may be delegated to him by the Executive Committee." This proposed change was included in the motion made above by Mr. Garnatz regarding the change in Article IV, Section 4 (*d*). Both amendments were seconded by W. Platt, and carried.

Dr. Geddes then called for the report of the Nominating Committee. R. W. Mitchell made the following nominations and moved their adoption as the report of his committee: President, G. F. Garnatz; Vice-President, C. F. Davis and Paul Logue; Secretary, J. M. Doty; Treasurer, Oscar Skovholt; Editor-in-Chief, M. J. Blish; Managing Editor, R. M. Sandstedt. Seconded by H. K. Parker. Carried.

Pearl Brown moved the nominations for President be closed and that the Secretary be instructed to cast a unanimous ballot for George Garnatz for President. Seconded by C. G. Ferrari. Carried.

J. R. Davies nominated C. H. MacIntosh for Vice-President. Seconded by J. A. Dunn. Carried. The names appearing on the first ballot for Vice-President were Paul Logue, C. F. Davis, and C. H. MacIntosh. Acting tellers were C. G. Ferrari, M. A. Gray, and C. H. Bailey. The first ballot gave MacIntosh 55 votes, Davis 54, and Logue 50.

Dr. Frey moved that all names be left on the ballot for the second time. If no man was elected on the second ballot, then the low man should be removed for the third ballot. Seconded by C. O. Stamberg. Carried. The second ballot gave

MacIntosh 57 votes, Davis 54, and Logue 51. Paul Logue's name was removed from the third ballot.

During the time of the third balloting, President Geddes called on C. F. Davis, Chairman of the Committee on Standardization of Laboratory Baking, to give his general report of the work of his committee. The three papers following Mr. Davis' report were also given during the balloting.

Paper—"Control of Dough Temperatures in Test Baking," by J. G. Malloch.

Paper—"The Use of Hand Operated Sheeting Rolls in Test Baking," by J. A. Shellenberger.

Paper—"Studies of the Usefulness of a Motor-Driven Sheeter in Test Baking," by Paul P. Merritt and Max C. Markley. Read by Max C. Markley.

The Chairman called on the tellers to report the result of the third ballot, and this report showed C. F. Davis the new Vice-President. Nominations for Secretary were opened. H. D. Liggitt moved the nominations be closed and that the Secretary be instructed to cast a unanimous ballot for J. M. Doty as Secretary. Seconded by W. Platt. Carried.

Dr. Geddes opened the nominations for Treasurer. E. B. Working moved the nominations for Treasurer be closed and that the Secretary be instructed to cast a unanimous ballot for Oscar Skovholt for Treasurer. Seconded by E. E. Smith. Carried. The nominations for Editor-in-Chief of *Cereal Chemistry* were opened. Paul Logue made the motion that the Editor-in-Chief and Managing Editor be elected at the same time since they worked together so closely. He moved that the nominations for these offices be closed and that the Secretary cast a unanimous ballot for M. J. Blish and R. M. Sandstedt for these offices in the order named. Seconded by C. H. MacIntosh. Carried.

R. C. Sherwood moved that Oscar Skovholt be appointed Treasurer until the end of the calendar year by the Executive Committee. Seconded by C. N. Frey. Carried.

W. Platt moved that the business session be closed. Seconded by M. A. Gray. Carried.

Dr. Geddes called C. F. Davis to the platform for a few words. Mr. Davis thanked the members and promised his best efforts for the Association. Dr. Geddes then called Dr. Larmour to the speaker's table to take over his duties as Presiding Chairman of the morning session. Dr. Larmour called on Dr. Markley for the next paper.

Paper—"Report on a Compromise Test Baking Pan," by M. C. Markley.

Paper—"Gas Retention as Affected by Including Shortening in the Tentative A.A.C.C. Basic Test Bake Formula," by W. L. Heald. This concluded the papers given by the Committee on Standardization of Laboratory Baking.

Paper—"A Study of Baking Methods for Evaluating the Quality of Hard Winter Wheats," by K. F. Finney and Mark A. Barmore. Read by Mr. Finney.

Dr. Larmour turned the meeting back to President Geddes, who recessed the meeting until 2:15 p.m. Recess was called at 1:10 p.m.

The afternoon session was opened at 2:15 p.m. with President-elect Garnatz presiding. He called on H. W. Putnam, Chairman of the Committee on Methods of Testing Soft Wheat, for his general report. Mr. Putnam, however, said he would give his report after the papers given by the members of his committee. Mr. Garnatz then called for the following papers:

Paper—"Report of Sub-Committee on Methods of Testing Cake Flours," by J. W. Montzheimer. Read by W. E. Stokes.

Paper—"Standardization of Methods for the Scoring of Test Cakes," by O. E. Stamberg.

Paper—"Comparative Study of the Results Obtained with Seven Commercial Type Cake Formulas in the Evaluation of Cake Flour Quality," by Francis J. Coughlin and Donald Wade. Read by Donald Wade.

Paper—"Discussion of Display of Cakes Baked from Seven Commercial Cake Formulas," by William R. Green.

Paper—"Report of Sub-Committee on Methods of Testing Self-Rising and Phosphated Flours," by O. E. Gookins.

Paper—"Report of Sub-Committee on Methods of Testing Biscuit and Cracker Flours," by Howard M. Simmons.

Paper—"General Report of the Committee on Methods of Testing Soft Wheat Flours," by H. W. Putnam. This summary concluded the papers presented by this committee. Mr. Garnatz introduced the next paper on the program.

Paper—"Checking," presented by Jan Micka.

Paper—"Fat Acidity in Relation to Heating of Corn in Storage," by Lawrence Zeleny. Because of the length of the afternoon program, Mr. Garnatz asked Dr. Bayfield if he could present his paper the first thing on the Thursday morning session. Dr. Bayfield agreed and Mr. Garnatz recessed the Wednesday session at 5:25 p.m.

At 7:00 Wednesday evening, the annual dinner dance was held in the Roof Garden of Hotel President. The Local Arrangements Committee had planned an excellent program including dinner, floor show, and dancing.

## THURSDAY, MAY 25

Dr. Sherwood, Chairman, called the meeting to order at 9:17 a.m. He immediately called on Dr. Bayfield for his paper, which had been held over from the Wednesday afternoon session.

Paper—"Observations Indicating the Need for Controlled Mill Room Conditions in Experimental Milling," by E. G. Bayfield.

The next part of the program was turned over to the Committee on Methods of Analysis, R. M. Sandstedt, General Chairman. Dr. Sherwood called for the following papers:

Paper—"Collaborative Study of the 15-Minute Moisture Method in Comparison with the Official Air-Oven Method II," by H. W. Putnam.

Paper—"A Physical Method of Determining Flour Value, Making Use of Gas Retention," by W. L. Heald.

Paper—"Proteolytic Activity Determinations in Cereal Products," by F. C. Hildebrand.

Paper—"The Pressure Meter in the Study of Yeast," by J. M. Doty and W. R. Urban. Read by J. M. Doty.

Paper—"General Report of the Committee on Methods of Analysis," by R. M. Sandstedt. Dr. Sherwood then called on Elsie Singruen to make a report for the Malt Analysis Standardization Committee. Mr. Rumold, Chairman of the Local Arrangements Committee, made some announcements and asked the members to decide on their preferences as to the inspection trips scheduled for the afternoon. Dr. Sherwood called for the following papers:

Paper—"Vitamin $B_1$ Content of Wheat, Flour, and Bread," by Alfred Shultz, Lawrence Atkin, and C. N. Frey. Presented by Dr. Frey.

Paper—"A Method of Determining Vitamin $B_1$ using the Fluorophotometer," by D. J. Hennesy.

Paper—"Some Applications of Time Lapse Ciné-Photography to Cereal Chemistry," by William Schanzenbach and Quick Landis. Read by Dr. Landis.

Paper—"Flour Changes on Storage in Different Types of Bags," by William H. Cathcart. Dr. Sherwood recessed the morning session at 11:55 p.m.

The Presidents' Luncheon was held in the Walnut Room of the hotel for the installation of the new officers. During the luncheon R. A. Barackman made and moved adoption of the following resolution:

"Inasmuch as the American Association of Cereal Chemists is deeply indebted to Dr. W. F. Geddes for the excellent manner in which he has directed the affairs of the Association during the past year,

"Be it resolved that we, the members of the Association, hereby express to Dr. Geddes our sincere appreciation of the many services which he has rendered in our behalf;

"Be it further resolved that a memorial be prepared and presented to Dr. Geddes whereby his services to the Association will be suitably commemorated."

Thursday afternoon was taken up with inspection trips to the Sheffield Steel Company, Corn Products Refining Company, the Research Laboratory of Campbell-Taggart Research Corporation, and the Goetz Brewing Company, all of Kansas City.

## FRIDAY, MAY 26

Officers of the National Association met with the officers of the Local Sections for breakfast in Room 229, Hotel President, at 8 a.m.

Dr. Blish, presiding officer for the Friday morning session, called the meeting to order at 9:20 a.m. He immediately called for the following papers.

Paper—"Dough Oxidation and Mixing Studies. IV. Effect of Oxygen and Oxidizing Salts on Sponge Doughs," by J. Freilich and C. N. Frey. Read by J. Freilich.

Paper—"Effect of Temperature on Dough Properties, II," by M. D. Mize and J. C. Baker. Given by J. C. Baker.

Paper—"Maltose Fermentation in the Dough," by A. L. Shultz, Lawrence Atkin, and C. N. Frey. Read by C. N. Frey.

Paper—"Effect of Fumigation on Whole Wheat Flour," by Frank James.

Paper—"The Permeability of Bread by Air," by J. C. Baker.

Paper—"Effect of Storage Temperatures upon the Viability and Baking Properties of Compressed Yeast," by M. T. Bartram, S. C. Rowe, and L. H. Bailey. Read by L. H. Bailey.

Dr. Blish turned the meeting back to Dr. Geddes. Because some of the members had expressed the desire to get away as soon as possible after the afternoon session, Dr. Geddes suggested that that session start earlier than scheduled. Members indicated by a hand vote that they would like to start at 1:15 p.m. instead of at 2:00 p.m. The morning meeting was recessed at 11:45.

The Friday afternoon session was called to order at 1:30 by W. L. Heald, the presiding officer. He called on Washington Platt, Chairman of the Resolutions Committee, to make a report for that committee. Mr. Heald then called on the speakers who presented the following papers.

Paper—"Starch in Relation to Some Baking Properties of Flour," by R. M. Sandstedt, C. E. Jolitz, and M. J. Blish. Read by R. M. Sandstedt.

Paper—"Starch as a Factor in Dough Formation," by O. E. Stamberg.

Paper—"Studies on Wheat Starch Fractions," by O. E. Stamberg. Mr. Heald then turned the meeting over to Dr. Geddes for the business session. Dr. Geddes asked for formal adoption of the report of the Committee on Methods of Analysis. J. M. Doty moved the adoption of the report as given by Mr. Sandstedt. Seconded by C. H. MacIntosh. Carried. W. O. S. Meredith moved the adoption of the report of the Malt Analysis Standardization Committee as given by Miss Singruen. Seconded by Quick Landis. Carried. Quick Landis gave a report for the Committee on Definition of Technical Terms. Dr. Landis moved the adoption of this report. Seconded by M. A. Gray, carried. C. F. Davis, Chairman of the Committee on Standardization of Laboratory Baking, moved the adoption of the report as given. Seconded by Elise Shover. Carried. Mr. Putnam moved the adoption of the report of the Committee on Methods of Testing Soft Wheat Flour and its three Sub-Committees. Seconded by Oscar Skovholt. Carried. Washington Platt moved the adoption of the Report of the Resolutions Committee. Seconded by C. F. Davis. Carried.

Dr. Geddes called C. H. MacIntosh, Chairman of the Program Committee, to the platform and thanked him on behalf of the Association for the excellent program he had arranged. Dr. Geddes also thanked everyone who had served on Mr. MacIntosh's committee. Mr. MacIntosh thanked the Association members for placing their confidence in him and said that he had enjoyed the work. Dr. Geddes then asked those present to applaud Mr. MacIntosh to show their appreciation of his efforts. Dr. Geddes asked for Perie Rumold, but since he was not present, Dr. Geddes expressed the appreciation of the Association to W. L. Heald of the Local Arrangements Committee. The retiring president thanked Mrs. Rumold for the excellent program she and her committee had arranged for the women present at the Annual Meeting.

Dr. Geddes thanked the members for their fine cooperation and good fellowship during his term as President. He then turned the gavel over to the new president, Mr. Garnatz.

President Garnatz gave a partial list of the various committee appointments. He pointed out that two of the committees would be discontinued, namely the Committee on Requirements for Membership and the Traffic Committee.

J. A. Dunn moved that the meeting adjourn. Seconded by D. A. MacTavish. Carried. President Garnatz adjourned the Twenty-Fifth Annual Meeting at 3:35 p.m.

## REGISTRATION OF CONVENTION, KANSAS CITY, MO.

**May 22–26, 1939**

### MEMBERS

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F. W. Albro
Geo. L. Alexander
J. A. Anderson
Arlee A. Andre
Hy H. Arendall
C. A. Armstrong
Lowell Armstrong
Charles C. Armuth
W. G. Artis

C. H. Bailey
L. H. Bailey
John C. Baker
R. A. Barackman
M. A. Barmore
E. G. Bayfield
Kurt Becker
H. N. Bergsteinsson
J. P. Bishop
M. J. Blish
R. T. Bohn
O. R. Borngesser
L. R. Bowman
D. L. Boyer
C. W. Brabender
T. A. Brantley
G. S. Bratton
C. L. Brooke
Mary M. Brooke
E. B. Brown
Lionel G. Brown
Pearl Brown
P. J. Buchanan
Geo. H. Buford
Howard Burrus
F. C. Buzzelle

Frank Carr
W. H. Cathcart
Howard A. Clark
Lee E. Clark
Rowland Clark
W. S. Claus
F. A. Collatz
Winthrop R. Corey
C. H. Crawford
A. E. Curtis

John R. Davies
Claud F. Davis
G. A. Davis
W. J. Davis
A. D. Dickson
J. M. Doty
F. L. Dunlap
J. O. Dunlap
J. A. Dunn
R. K. Durham

W. G. Epstein
C. F. Evert

H. S. Faulkner
C. G. Ferrari
G. E. Findley
K. F. Finney
V. E. Fisher
Henry Flick
J. T. Flohil
E. N. Frank
J. Freilich
C. N. Frey
R. L. Frye

Miss B. Galletly
Geo. Garnatz
W. F. Geddes
H. O. Gilmer
C. A. Glabau
E. F. Glabe
Phil Goodwin
O. E. Gookins
M. A. Gray
P. P. Gray
W. R. Green
N. L. Gregory
Arthur W. Gust

L. W. Haas
T. L. Haberkorn
Harold Hall
Robt. W. Haman
C. G. Harrel
R. H. Harris
William Hauck
W. L. Heald
F. C. Hildebrand
E. V. Holm
Ray Horn
Geo. L. Howard
H. P. Howells
H. S. Hutchinson

Bert D. Ingels
Roy Irvin

L. E. Jackson
Frank James
W. G. Jantzen
H. H. Johnson

Chas. H. Keipper
A. J. King
H. W. Kingsbury
G. W. Kirby
R. N. Knudson

A. L. Lancaster
O. Landis
R. K. Larmour
Stephen Laufer
S. J. Lawellin
F. H. Lawford
L. E. Leatherock
H. L. Lentz
H. D. Liggitt
Paul Logue
K. H. Lorenz
H. J. Loving
J. M. Lugenbeel
F. J. Lumsden

C. H. MacIntosh
D. A. MacTavish
M. C. Markley
Miss E. L. Martin
Victor E. Marx
J. E. Mastin
R. E. McCormick
Harold W. McGhee
R. M. McKinstrie
L. H. McLaren
Nell McNeil
W. O. S. Meredith
J. B. Merryfield
W. C. Meyer
Jan Micka
P. E. Minton
R. W. Mitchell
M. D. Mize
Elmer Modeer
G. Moen
Claude L. Moore
Ray E. Moser

C. T. Newell

Harry Obermeyer
C. O. Oppen
T. J. Otterbacher
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M. H. Parlin
C. W. Partridge
C. J. Patterson
F. D. Patterson
Frank Paul
Earl C. Paulsel
Grant W. Pearcy

L. W. Pingree
Perie R. Pitts
Washington Platt
R. B. Potts
R. A. Pouchain
Ray Powers
H. W. Putnam
Glenn L. Pyle

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O. H. Raschke
Christian Rask
L. Reimers
Whitman Rice
C. E. Rich
Thos. C. Roberts
W. L. Roberts
Hugo W. Rohde
W. C. Rohrbaugh
K. S. Rohrbough
Perie Rumold

R. M. Sandstedt
T. W. Sanford
A. R. Sasse
J. S. Schlesinger
J. A. Shellenberger

R. C. Sherwood
V. Shiple
Elise Shover
Fred P. Siebel, Jr.
R. V. Siebel
Howard M. Simmons
Miss E. Singruen
O. P. Skaer
Oscar Skovholt
E. E. Smith
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W. E. Stokes
Joe Stoklas
J. D. Stone
D. F. Stutzman
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C. O. Swanson

G. D. Thevenot
W. Tholstrup
L. M. Thomas
E. F. Tibbling
W. M. Tinkham

A. A. Towner
Carl E. Turner
L. C. Tuttle

G. G. Van Patten
W. V. Van Scoyk
C. G. Vaupel
E. A. Vaupel

Donald Wade
C. C. Walker
H. G. Walter
Jack Ward
T. R. Warren
Peter J. F. Weber
John S. Whinery
J. W. Whitacre
Robert Whiteside
H. M. Wight
Martin Wise
Carl E. Witter
E. B. Working
W. W. Worzella
Charles B. Wright

Lawrence Zeleny

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Mrs. C. L. Brooke
Mrs. E. B. Brown
Mrs. G. H. Buford
G. M. Burkert
B. A. Burkhart
Mrs. Howard Burrus

R. D. Callaway
G. T. Carlin
Mrs. Rowland Clark
Mrs. W. S. Claus
Mrs. F. A. Collatz
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Mrs. Claud Davis
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V. F. Duensing
Mrs. R. K. Durham

Joseph Eichberg
J. J. Enright
Mrs. C. F. Evert

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Tom Ferguson
Mrs. C. G. Ferrari
Mrs. G. E. Findley

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Mrs. E. N. Frank
Mrs. Rolfe L. Frye

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Mrs. O. E. Gookins
Bob Graham
Mrs. P. P. Gray
Mrs. Wm. R. Green
Mrs. Arthur Gust

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Walter S. Hale
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Mrs. W. L. Heald
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Mrs. Ray Horn
Mrs. Geo. L. Howard
Mrs. H. P. Howells

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Mrs. L. H. McLaren
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Mrs. R. W. Mitchell
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V. E. Munsey

Milton E. Nelson
Mrs. Milton E. Nelson
Mrs. C. T. Newell
A. I. Newman
H. E. Noelck

Mrs. Harry Obermeyer
Frank Osborn

John H. Parker
Geo. T. Peckham
A. Pitann
Mrs. R. B. Potts
Mrs. R. A. Pouchain
R. W. Pratt
Mrs. R. W. Pratt
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Mrs. C. G. Vaupel
S. S. Voris
Mrs. S. S. Voris

C. Weaver
R. L. Watkins
Mrs. John S. Whinery
Mrs. J. W. Whitacre
Mrs. Robert Whiteside

## REPORTS OF COMMITTEES

### The Executive Committee

GEO. GARNATZ, *Chairman*

President Geddes, in his address Monday morning, reported on the state of the Association and indicated that a detailed account of the business activities would be included in the report of the Executive Committee. The following therefore is submitted for the approval of the membership and constitutes a report of the actions taken by the Executive Committee in conducting interim business and passing on matters of policy.

Several proposals were submitted to the committee by mail and in addition meetings were held in Cincinnati on May 26, 1938; in Chicago on March 15, 1939; and in Kansas City on May 21, 1939.

With the knowledge and consent of the committee and on authorization by President Geddes, the Committee on Membership Requirements prepared the results of their studies on this subject in the form of constitutional revisions. Those portions of the constitution thus affected were set up in comparison with the revisions, and, in conformity with the requirements for amending the constitution, were mailed out to the membership in time to qualify for action at this meeting.

In last year's Executive Committee report, a recommendation was made that some consideration be given toward providing a part time paid employe to relieve some of the officers of certain burdensome routine duties and to eliminate duplication of effort through centralization of certain business activities. In accordance with this recommendation a constitutional amendment is proposed which will make it possible for the Executive Committee to appoint at their discretion an Assistant Treasurer.

These provisions are considered adequate and flexible and contemplate consolidation of this work in the office of the Managing Editor of *Cereal Chemistry*, elimination of duplication of effort there and in the treasurer's office and at the same time relieving the treasurer and secretary of burdensome routine details. It is the recommendation of the Executive Committee that favorable action be taken on this proposal.

The treasurer has recommended to the Executive Committee the desirability of having the treasurer assume office on a calendar-year basis rather than immediately following the annual meeting, in order to eliminate the mid-term audits and to permit a more orderly and business-like transfer of duties. It is recommended that favorable action be taken by the Association.

Twelve applications for membership which were referred to the Executive Committee were favorably received.

By invitation from the American Society of Bakery Engineers, the Association participated in their program largely through the Committee on Cooperative Research and also arranged for a paper on "Boiler Water Treatment, Scale Formation,

and Pipe Corrosion" by D. W. Haering. S. J. Lawellen also presented a paper dealing with the sanitation aspects of water supplies.

The budget for 1939 was adopted as presented by the treasurer.

The surplus ($339.63) resulting from the Cincinnati meeting was turned over to the Executive Committee by the Cincinnati Section. This was accepted with thanks and allocated to the general fund of *Cereal Chemistry* to be used in printing additional papers at the discretion of the Editor-in-Chief.

It was agreed to close the account with the Harris Trust and Savings Bank of Chicago and, upon the recommendation of the Investment Committee, to invest $4,500.00 of the Association's surplus funds in U. S. Savings Bonds yielding 2.9%.

Consideration has been given to a request for the separate publication of the reference tables now included as an appendix to *Cereal Laboratory Methods*. These tables can be provided in a separate binding at approximately seventy-five cents per copy, and it was decided to delay action until a canvass of possible sales was made.

The proposal that national officers visit local sections was discussed and the Executive Committee proposes to designate up to $150.00 annually for this purpose, which is to meet approximately 50% of the expenses incurred, the participating sections to meet the rest of the expenses. Requests are to originate from the sections and will be passed on by the president of the Association.

It is realized that in certain sections the constitutional provision relative to the proportion of national association members required, is not being lived up to and accordingly the Executive Committee recommends to the succeeding committee that proper steps be taken to amend the constitution along such lines as are more practical and at the same time will assist the Membership Committee by encouraging the sections to seek eligible candidates who will ultimately seek membership in the national association.

Many routine matters of business were discussed and acted on, including arrangements for the present convention. Representatives of the New York Section renewed their invitation to the A. A. C. C. to meet in New York in 1940; invitations were also received to hold the 1940 meeting in Milwaukee, Louisville, Philadelphia, and Biloxi, Miss. In view of the overwhelming majority who favored New York in the post-card ballot, this city has been selected as our meeting place for 1940.

An invitation to meet in Omaha was received and filed for consideration when the rotation plan calls for the A. A. C. C. to meet in the southwest again and another invitation from Louisville as well as one from Columbus, Ohio, were similarly recorded.

The Auditing Committee recommended that in addition to the summarized items covering *Cereal Chemistry* in the treasurer's report, a detailed financial report covering the journal should be published. The editors of *Cereal Chemistry* and the Executive Committee concur in this recommendation.

Because of the necessity for the managing editor of *Cereal Chemistry* to be in close association with the editor-in-chief and because such an arrangement lends itself better to emergencies and transfer of duties the present Executive Committee recommends to the succeeding one that steps be taken to amend the constitution to make the office of Managing Editor appointive by the Executive Committee rather than elective.

In view of the increasing size of *Cereal Chemistry* and the increased membership, with resultant increased work for the Editor-in-Chief, Assistant Editor, and Managing Editor, the Committee recommends a more equitable remuneration for the services of these officers.

A communication was received from the group of Association members in Winnipeg, Canada, expressing the intent to form a Cereal Chemists' Club with the ultimate purpose in mind to form a Section when the group is firmly established.

Reports received by the secretary indicate that the several local sections are functioning actively and are cooperating closely with the Association officers and the Publicity Committee.

All in all it would appear that the affairs of the Association are being administered actively and that a healthy condition exists.

As chairman of the Executive Committee I desire to express my appreciation for the fine cooperation extended me by the members of the Committee and by Dr. Skovholt and Mr. Doty.

### The Committee on Investment

PAUL LOGUE, *Chairman*

Your committee recommended to the treasurer in February that the surplus funds then available be invested in bonds of the United States Government.

As further guidance in the investment policy of the Association in the future your committee suggests the following:

(1) Maintain a minimum average cash balance in the checking account equivalent to one month's average expenditures.

(2) Maintain in savings accounts the equivalent of three average months' expenditures.

(3) Maintain in readily marketable bonds of the United States Government funds equivalent to an average year's expenditures.

(4) After the above requirements have been met, invest funds to the extent of two years' expenditures in bonds of states, municipalities, and public utilities which have not defaulted on the interest of any bonds in the past 25 years, and which are approved for investment for insurance companies in the State of New York.

### The Auditing Committee

H. K. PARKER, *Chairman*

The Auditing Committee met with the treasurer February 16th for the 1939 audit. Our report in respect to the same will be found on page 300 of the March, 1939, issue of *Cereal Chemistry*.

In addition to this formal printed report we wrote to President Geddes that in our opinion there were funds available for investment and that such a move should be carried out to establish a safe limit, since the amount carried was well over the Federal Reserve guarantee of $5,000.

We also suggested that a report such as prepared by the managing editor of *Cereal Chemistry* should be included in the general treasurer's report so that the picture of the business done in respect to our publication would be a little more clear to the membership.

### The Employment Committee

CHARLES A. GLABAU, *Chairman*

The Employment Committee has had 28 applications for positions from cereal chemists, from January, 1938, to May, 1939.

Twenty cereal chemists have applied for positions from June, 1938, to May, 1939. During this same period, eight companies requiring the services of cereal chemists have applied to the Employment Committee for applicants. The committee has not been able to determine how many of these positions have been filled by candidates suggested.

The employment situation appears to have been somewhat better for cereal chemists over the past year.

The committee has given some thought to the development of an application blank which may be used in determining the qualifications a candidate may have when applying for a position as a cereal chemist. The committee hopes to have such a blank completed very shortly.

### The Membership Committee

D. A. MACTAVISH, *Chairman*

Your committee's efforts this past year have been directed along the same channels as in 1937–38, namely, a continuous endeavor to bring home to the membership as a whole, but more particularly the officers of the local sections, the necessity of maintaining and adding to the roll of active members of our national association. To this end we have made use of the space allotted to our committee in the various issues of the News Letter, have circularized the sectional chairmen, and sent personal letters to prospectives whenever a name or list of names has been given to us.

The treasurer has turned over to our committee for further attention (both in 1938 and 1939) lists of delinquents who had not responded to "final notices" and these

ex-members have had personal appeals sent out to them or their delinquency has been called to the attention of the chairmen of the local sections within whose geographical zone they formerly resided. In other words, we have been endeavoring not only to gain new members but to retain all of our old ones—or find out the reason for their secession. All in all, our efforts in both directions have met with some degree of success.

We are happy to report as of today a *total of 613 members* in good standing as against 570 at this time last year or an *increase* over the corresponding period in 1938 of 8.0% *Forty new active members and two new corporation memberships have been added this year, as against 38 active and four corporation memberships last year.* In addition, four members from previous years have been reinstated for a gain of 44 active members for the current year. A survey, as of the 6th of May last, shows the following standing as to membership in the local sections:

*In Active Membership*

8 sections with an increase
2 sections no change
2 sections with a decrease
1 section not heard from.

*In Associate Membership*

8 sections with an increase
1 section no change
2 sections with a decrease
2 sections not heard from.

As was called to your attention last year, we again find a few sections out of balance in the proportion of associate to active members. However, we know the officers of these sections are making every effort to bring about a better proportionate relationship in this respect. There are a number of them who feel that it is essential to the well-being of, and sustained interest in, their meetings to make use of a large associate membership, among whose ranks are many who actually would not qualify as, or do not wish to become, members of the national association. We appreciate and endorse that point of view.

The year 1939 promises to be a banner year in sustained growth both numerically and in the quality of membership attracted to our Association.

In conclusion, allow me once more to thank the members of the committee, particularly the chairmen of the local sections for their continued and effective cooperation during this past year. To them the major portion of credit should, for such a satisfactory showing, be extended.

**The Membership Requirements Committee**

R. C. SHERWOOD, *Chairman*

At the annual meeting in Cincinnati, 1938, the Membership Requirements Committee reported its activities and suggested changes in the constitution. President Geddes reappointed the committee with instructions to draft proposed amendments to the constitution embodying the recommendations of the committee. This work was completed a few months ago, and reported to President Geddes. Under date of February 13, 1939, mimeographed copies of the proposed revisions were distributed to all active members of the Association for their consideration. The proposed revisions are made a part of this final report. The committee has now completed the work assigned to it.

(Editor's note: see secretary's minutes for report of action taken on proposed amendments.)

**The Inter-Relations Committee**

C. G. HARREL, *Chairman*

Sometime during the early part of January, 1939, it was my privilege to be appointed to the chairmanship of the Inter-Relations Committee. Because of this rather late appointment, it has not been feasible during this short time to hold as many committee meetings or communicate with the committee as often as would be desired. In order that some definite program might be made, it has been necessary

for the chairman to start immediately certain work in regard to the issuing of invitations and programs. It is hoped that this will meet with the approval of the association as a whole, as well as the members of my committee.

In March, 1939, the Inter-Relations Committee, in cooperation with the Northwest Section of the American Association of Cereal Chemists, assisted in preparing a program which was held at the Leamington Hotel on March 31st. Copies of the printed program were sent to approximately 500 officials of the various milling and baking organizations throughout this country, as well as heads of educational institutions. Invitations to this program were likewise sent to members of our Northwest Section and to chairmen of local sections of the A. A. C. C.

On May 12, 1939, 270 letters were addressed to the executives of the milling and baking organizations in this country extending to them a most cordial invitation to be present at our meeting in Kansas City. Through the cooperation of the local committee of the Kansas City Section, we obtained a list of 163 high schools, junior colleges, and universities, which was carefully prepared by Dr. Wildish, of the Kansas City Junior College. These 163 educational institutions are located in and around Kansas City. A letter was written extending to them a cordial invitation to be present at one or more of our meetings which are now in progress. Along with the letter written to the industrial organizations and educational institutions, a copy of the preliminary report of the Program Committee, which appeared in Volume 47 of the News Letter issued in April, 1939, was attached.

I wish to report that our communications, which have been written since the first of the year, amount to approximately 1,000 letters.

### The Committee on Definitions of Technical Terms

QUICK LANDIS, *Chairman*

During the last year the committee has maintained a general survey of our field in order to recognize any serious ambiguity in terminology. We would like to call your attention to the recent publication of two dictionaries of scientific terms even though they may contain few of our own specialized terms, namely: *Standard Chemical and Technical Dictionary*, by H. Bennett, and *Dictionary of Scientific Terms*, by C. M. Beadnell.

It is the purpose of the committee to complete the collection of definitions of biometrical terms and to publish them under the authorship of C. L. Brooke, in a convenient form for ready reference.

If a sufficient demand should develop, it is believed that somewhat extended definitions for terms used in baking technology and cereal chemistry might profitably be undertaken. If these were so constructed as to appeal both to lay and technical individuals, a desirable unification of thought might be encouraged.

The circumstances under which this committee was first conceived have been, we believe, improved. Much of this improvement has arisen from extensive investigations and from the resulting advancement of scientific knowledge. We trust, however, that the efforts of the committee may have been of some assistance in this connection.

For the last few years our conventions have been singularly free from discussions arising from serious ambiguities in the use of technical terms. It therefore appears that the Committee has served its purpose and it is recommended that it be discharged.

### The History Committee

ROWLAND J. CLARK, *Chairman*

The History Committee wishes to express its deep appreciation to the Publicity Committee, to the sectional secretaries, the Association officers, and to the other individuals who have, during the past year, contributed to the historical files of our organization. Through the splendid cooperation of all these members, announcements of meetings, descriptions of programs, magazine clippings, together with other valuable historical records, have all been preserved in our organization's scrapbook.

Events become significant or fade into the mist of forgotten years in proportion to their influence on future trends of action. It is difficult to determine the true importance of an event until it is viewed in the light of past history. Therefore it is necessary for the History Committee to preserve all evidence and data pertaining to the Association's activities in order to evaluate rightly the course pursued.

Apparently cereal chemists stand higher in the esteem of the industry today than they did a year ago. There was a day when in times of depression the cereal chemist was the first to suffer. Now we have one of our leading milling executives stating in the columns of the News Letter: "The cereal chemist has been called to the rescue of the cereal-products industry." How welcome, yet how ludicrous, this statement would have sounded twenty-five years ago. Of course the cereal chemist has always been convinced of its truth; but it has taken time, patience, and hard toil to prove to the industry that chemical research holds the key to future progress. It seems that this recognition is an event that can be properly evaluated immediately because it partially reaches a goal toward which the Association has been striving for a quarter of a century.

The American Association of Cereal Chemists will this week render an accounting of its past year's work. History will be unfolded. The eyes of the industry are upon the actions of this gathering. The past twenty-five years are studded with vivid memories of accomplishments. The next twenty-five years can be made even greater.

### The Traffic Committee

G. NORMAN BRUCE, *Chairman*

The duties of the Traffic Committee are to list the most convenient routes to the national meeting, which were duly reported and listed in the News Letter. Experience on this duty for the past three years leads the present chairman to the opinion that the traffic arrangements are naturally a function of the convention arrangement program and should be handled by the convention committee through the chairman of each local section. The local chairman could appoint a traffic-wise member in each group to handle details and report to the convention committee for listing in the News Letter.

### The Committee on Osborne Medal Award

R. W. MITCHELL, *Chairman*

This committee functions somewhat differently from most committees of our society. While most of our committees strive to get work done with dispatch this committee is charged with the responsibility of going slowly. Our society has expressed a desire to have the Osborne medal represent its expression of tribute to very unusual accomplishment in the field of cereal chemistry.

During the past year the several names have been considered but the committee has chosen to move slowly so that time may permit a crystallization of sentiment. We come to you at this time to recommend that there be no award of the medal now, and that our action be reviewed by the committee during the coming year. In that way the Association will have the assurance afforded by the deliberations of two committee groups that the dignity of the award is being jealously guarded.

### Report of the Secretary

J. M. DOTY

The secretary has very little to report. The usual routine letters were written. A total of 2,423 carbon copies of letters written from May 1, 1938, to May 1, 1939, are now in his files.

### The Committee on Resolutions

WASHINGTON PLATT, *Chairman*

Whereas, the American Association of Cereal Chemists has again enjoyed a most successful year of activity and a profitable and enjoyable annual meeting; and

Whereas, this success has in large measure been due to the services so generously and efficiently rendered by the officers and committees of the Association,

Therefore be it resolved that the sincere appreciation of this Association be expressed to the officers who have served during the past year: President, W. F. Geddes; Vice-President, G. F. Garnatz; Secretary, J. M. Doty; Treasurer, Oscar Skovholt; and to the Program Committee, C. H. MacIntosh, Chairman; the Local Arrangement Committee, Perie Rumold, Chairman; The Ladies' Entertainment

Committee, Mrs. Perie Rumold, Chairman; and to all other committees who by their contributions have made the year's work so successful.

Be it further resolved that we express our appreciation for the services of M. J. Blish, Editor-in-Chief of *Cereal Chemistry*, and to R. M. Sandstedt, Managing Editor, and to their associates on the business and editorial staff of *Cereal Chemistry* for their excellent work during the year just passed.

Be it further resolved that we express our thanks to the Rev. David H. Owen, who delivered the invocation at our opening session.

Be it further resolved that we express our thanks to the Hon. Bryce B. Smith, Mayor of Kansas City, for the delightful talk and fine welcome which he extended to the Association on behalf of Kansas City.

Be it further resolved that we express our thanks and appreciation to those whose assistance and cooperation with the Local Arrangement Committee have contributed materially to the success of the many and varied features of our meeting namely:

To the following as donors of the shooting and golf prizes: Mr. Joe Hinckle of the Elliott Arms; Mr. O. L. Davis of Angler's Supply House; Mr. LeRoy Brouse of Gateway Sporting Goods; and Mr. R. J. Clark of Power and Light Co. (all of the foregoing being located in Kansas City, Missouri), American Agricultural Chemical Co., Anheuser-Busch, Inc., Durkee Famous Foods, Laboratory Construction Co., Monsanto Chemical Co., Precision Scientific Co., Standard Brands, Inc., Victor Chemical Co., and Wallace and Tiernan Co.

Be it further resolved that we express our thanks to the Manor Baking Co. for the handsomely decorated birthday cake symbolizing the twenty-fifth anniversary of the founding of this Association, and to the following firms for their hospitality in inviting the members of the Association for field inspection trips: Corn Products Refining Co., Goetz Brewing Co., Research Laboratory of Campbell-Taggart Research Corp., and Sheffield Seel Co.

Also to Mr. Adrian Hooper, Assistant Manager of the President Hotel, Kansas City, and to his staff and the Kansas City Chamber of Commerce.

And whereas the Association of Operative Millers will hold their annual meeting in Kansas City June 5th to 9th,

Be it resolved that we extend to them our best wishes that they may have a successful meeting and the expression of our anticipation of another year of continued cooperaton between our two associations.

Whereas the American Society of Bakery Engineers generously granted to the American Association of Cereal Chemists a liberal portion of the program of their annual meeting and whereas Mr. William Hauck, President of the Society of Bakery Engineers, has kindly taken part in our own annual meeting,

Be it resolved that the Association renew its expression of the mutual value of the close cooperation and friendly spirit which has existed between these two organizations for so many years.

Be it resolved that the Association express its thanks to our guest speakers Dr. E. R. Weidlein, Dr. John H. Parker, and Dr. D. J. Hennesy, all of whom did so much to make our opening meeting an inspiration to cereal chemists.

Be it resolved that the Association express its thanks to Sergeant D. E. Bates and Mr. Francis M. O'Connor of the Kansas City Police Department for their exhibition of skill and courage in connection with our outing.

Be it resolved that the secretary be instructed to send a copy of an appropriate extract from these resolutions to each individual or organization named herein.

Be it resolved that we express our deep regret at the passing of loyal member A. D. Barbour, and be it further resolved that the Secretary be instructed to convey to his family the deep and heart-felt sympathies of the Association.

## BOOK REVIEW

**Durum Wheats and Their Utilization.** By Carl L. Alsberg. Volume 15, No. 7, of *Wheat Studies of the Food Research Institute*, Stanford University, California. 27 pages. Price 75 cents. April, 1939.

This publication presents in compact form an up-to-date picture of the world situation as regards durum wheats and durum wheat products. Origin, distribution, botanical features, and agronomic and cultural characteristics of durum wheats are indicated, and our present knowledge of the physical and biochemical properties of the grain itself is adequately set forth.

Going back to ancient times, all of the known methods of utilizing durum wheats are discussed, and the essential features of macaroni manufacture are described. Numerous and well chosen literature references are given for the benefit of those who may wish to consult original sources for more detailed information.

No one interested in durum wheat or in durum wheat technology can afford to be without a copy of this publication.

M. J. Blish

## GLASS BLOWING MANUAL

The Laboratory and Pharmaceutical Division, Corning Glass Works, Corning, New York, has recently published a manual "Laboratory Glass Blowing with 'PYREX' brand Glass."

This manual is offered as an aid to the laboratory technician. It contains information on the working characteristics of "PYREX" brand Glass, an explanation of fundamental glass blowing operations, and recommendations of suitable tools and equipment. The manual will be supplied without charge, upon request, to users of Corning Glass Works' laboratory glassware.